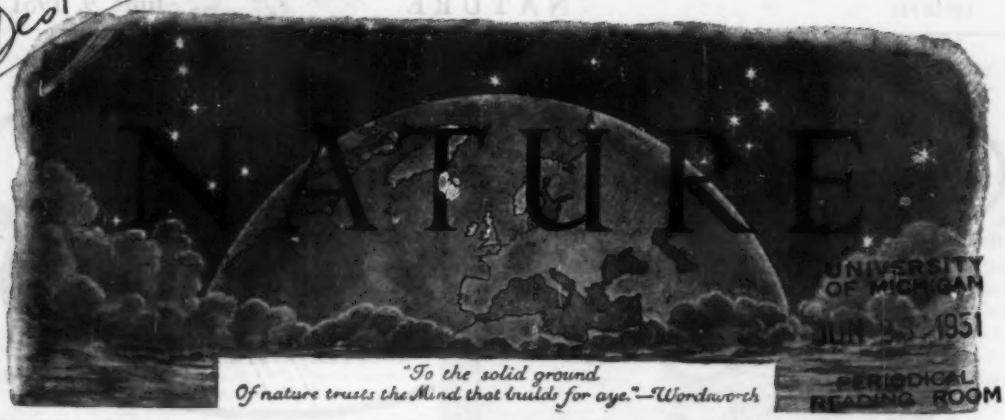
Desk



UNIVERSITY OF MICHIGAN
JUN 25 1951
PERIODICAL READING ROOM

VOL. 167, NO. 4258 SATURDAY, JUNE 9, 1951 ONE SHILLING & SIXPENCE

More room to work
The Newton Long Working Distance Microscope Attachment increases object distance to 12.8 m.m. when used in combination with a standard 4 m.m. or 8 m.m. objective.
This is achieved by means of a mirror system optically corrected and possessing the further advantage that image reversal is eliminated.
Newton

Dept. W 27, NEWTON & CO., LTD., 72, Wigmore St., London, W.1
Associated with Metropolitan-Vickers Electrical Co., Ltd.

Tinsley

SENSITIVE LONG PERIOD GALVANOMETER

Type 4789

A very sensitive long period galvanometer for ballistic or insulation measurements

Resistance	Period	Sensitivity in mm./μα at 1 metre
17 ohms	20 secs.	1,500
850 ohms	20 secs.	25,500

Short delivery time

H. Tinsley & Co. Ltd., Werndee Hall, London, S.E.25
Telephone: ADDiscombe 1400 and 3600

ESTAB. C. BAKER LONDON 1765

VERNIER MEASURING MICROSCOPE

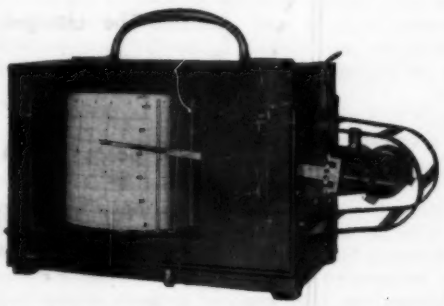
Invaluable for measuring and inspection purposes

200mm. range of movement with 12·5mm. fine adjustment travel. Vernier reads to 0·02mm. Can be used in six different positions. Stainless steel scales and verniers. Using an upright and telescope objective, the instrument is quickly converted to a cathetometer.

With + line eyepiece and 3 in. objective .. .. £20 10s.

C. BAKER of Holborn Ltd.
244 HIGH HOLBORN
LONDON, W.C.1
Phone: HOLborn 1427 & 4664
Member Scientific Instrument Manufacturers' Assn. of Gt. Britain

Temperature



Recorded on our BIMETALLIC TYPE Thermograph

NEGRETTI & ZAMBRA!
122 Regent Street, London, W.1

VACUUM LEAK DETECTION

An OLD Problem...

A NEW Solution

EDWARDS

PALLADIUM BARRIER LEAK DETECTOR

LEAK DETECTION, the constant worry of vacuum workers, is now most ably and conveniently mastered by the introduction of the Edwards Palladium Barrier Leak Detector.

Its sensitivity and specific response bring it within comparison with the mass spectrometer, but without its cost and complications.

W. EDWARDS & CO. (LONDON) LTD. LOWER SYDENHAM · LONDON · S.E.26

...For better vacuum service

30 YEARS VACUUM EXPERIENCE

Telephone: SYDenham 7026 (8 lines) Telegrams: Edcohivac, Souphone, London.

Important Announcement

Owing to the continued rise in the costs of production and of paper, the price of "NATURE" will be increased from 1s. 6d. to 2s. weekly as from July 7, 1951.

The charges for subscriptions will be

12 months	**...**	**£6 0 0**
6 months (26 issues)	**...**	**£3 0 0**
3 months (13 issues)	**...**	**£1 10 0**

postage paid to any part of the world

Orders for subscriptions should be placed with a bookseller or newsagent, or sent direct with remittance, to

Macmillan & Company, Ltd.,
St. Martin's Street, London, W.C.2

NATURE

No. 4258 SATURDAY, JUNE 9, 1951 Vol. 167

CONTENTS

	Page
Industry and the Universities	911
Industrial Research in Electronics. By A. H. W. Beck	912
They are not Marxists. By Prof. L. J. Russell	913
British Science and Technology since 1851. By R. Brightman	914
Developments in Astronomy. By Rev. Dr. M. Davidson	915
Design of Electrical Inductors. By Prof. J. Greig	915
Britain's Scientific Shrines (3). By Eng.-Captain Edgar C. Smith, O.B.E., R.N.	918
Evolutionary Trends and Classification. By Dr. H. G. Baker	921
Obituaries:	
Prof. Aimé Auguste Cotton. By Prof. L. F. Bates, F.R.S.	923
Mr. W. W. Davies, O.B.E. By Dr. T. Lonsdale	923
News and Views	924
X-Ray and Solubility Studies of the Hæmoglobin of Sickle Cell Anæmia Patients. By Dr. M. F. Perutz, Dr. A. M. Liquori and Dr. F. Eirich	929
Sickle-Cell Anæmia and Sickle-Cell Trait as Homo- and Heterozygous Gene-Combinations. By Dr. H. Lehmann	931
Effect of Thyroxine on Creatinephosphokinase Activity. By Brigitte A. Askonas	933
British Scientific Instruments in Paris. By Prof. G. I. Finch, F.P.S.	935
Television Station at Birmingham	935
Instability of Small Planetary Cores	936
1851 Exhibition Scholars: Centenary Dinner	937
Breeding Habits of the Swift	937
Physics of Lubrication	938
Letters to the Editors:	
Spiral Growth on Carborundum Crystal Faces.—Ajit Ram Verma; S. Amelinckx	939
Growth of Large Quartz Crystals.—C. S. Brown, R. C. Kell, L. A. Thomas, Dr. Nora Wooster and Dr. W. A. Wooster	940
Source Points of Radio Noise Bursts associated with Solar Flares.—Dr. M. A. Ellison	941
Radium and Deep-Sea Chronology.—Prof. Hans Pettersson	942
Spin of Sodium-24.—K. F. Smith	942
Polarization of the Z-Trace.—J. E. Hogarth	943
Yield Phenomenon and Twinning in α-Iron.—Dr. A. T. Churchman and Prof. A. H. Cottrell	943
Relaxation Spectrum of Glass.—Y. L. Yousef and R. Kamel	945
X-Ray Study of the Thermal Decomposition of Dolomite.—H. G. F. Wilsdorf and R. A. W. Haul	945
Effects of Triphosphopyridine Nucleotide upon Oxygen Evolution and Carbon Dioxide Fixation by Illuminated Chloroplasts.—L. J. Tolmach	946
Deoxyribonucleic Acid Content of the Egg of *Sabellaria* during Maturation and Fertilization.—Dr. J. Pasteels and Dr. L. Lison	948
Formation of Glycolaldehyde by Enzymic Scission of Pentoses.—R. Kaushal, P. Jowett and Dr. T. K. Walker	949
Functional Survival of Fowl Spermatozoa after Freezing at −79° C.—C. Polge	949
Sickle-Cell Trait in Yemenite Jews.—Dr. F. Dreyfuss and M. Benyesch	950
Presence of Foetal Hæmoglobin in Cooley's Anæmia.—Dr. A. M. Liquori	950
Relationship of Growth-Phase to the Reducing Activity of Bacterial Cells.—Dr. Paul H. Kopper	951
Some Host Relationships of the Potato-rot Nematode, *Ditylenchus destructor* Thorne, 1945.—V. E. Henderson	952
An Indigenous Source of Swollen Shoot Disease of Cacao.—J. Mc.A. Todd	952
Time of Egg-laying in the Planktonic Copepod *Calanus*.—Dr. J. P. Harding, S. M. Marshall and A. P. Orr	953
Volatile Fatty Acids in the Rumen of the Sheep.—F. V. Gray, A. F. Pilgrim, H. J. Rodda and R. A. Weller	954
Length of the Period of the Periodic System.—M. V. Tomkeieff	954

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831
Telegrams: Phusis Lesquare London

Advertisements only should be addressed to:
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2.
Telephone Number: Temple Bar 1942

All rights reserved. Registered as a Newspaper at the General Post Office

INDUSTRY AND THE UNIVERSITIES

NEARLY seven years ago, the provision by the directors of Imperial Chemical Industries, Ltd., for eighty fellowships at nine universities in Great Britain, to be held by senior workers in certain sciences, was warmly acclaimed in the scientific world. Since then the dependence of the British universities upon State grants has steadily increased, and while British eminence in pure science has been generally recognized, there has been some concern expressed as to the continuance of fundamental research on an adequate scale, more particularly because it is usually accepted that the biggest contribution to the immediate increase in industrial productivity will come from the application of existing, rather than from the search for new, knowledge. The universities themselves have been rightly concerned at the possible effect on their autonomy of increasing dependence on State grants, and the University Grants Committee has urged upon them the duty of seeking support from private sources.

Admittedly it is difficult in present circumstances to feel too hopeful about the prospects of private benefactions on a scale sufficiently large to offset that dependence on State support, and especially since sponsored research itself is liable to have serious repercussions on the economy of university departments. The objections to such research were well set forth last year in a report on the academic policy of the Massachusetts Institute of Technology, and, in his Jubilee Memorial Lecture to the Society of Chemical Industry last January, Prof. H. R. Kruyt also stated the reasons for the pursuit of entirely "non-directed" research at the universities.

It is accordingly welcome to learn from a recent article in *The Times* of April 21 by Prof. J. W. Cook, of Glasgow, that the board of Imperial Chemical Industries, Ltd., has informed the universities of its intention to enter into new covenants for the support of research fellowships when the present seven-year covenants expire. This is the largest, but not the only, project launched by big industrial concerns, which seeks to promote scientific research but without restrictive conditions. Prof. Cook, in directing attention to this group of benefactions, attempts to assess the benefits which they have already brought to the universities of Britain.

The scheme has helped to fill what, in Prof. Cook's view, would otherwise have been a serious gap in the provisions made for the post-war expansion of the universities of Britain. The emoluments of the I.C.I. Research Fellowship scheme have proved sufficient to attract able young men of proved capacity for research, as well as quite mature and experienced men of science, thus providing the universities with those senior research workers who are needed in considerable numbers if a university is to discharge one of its major functions, namely, carry out considerable fundamental research of high standard. The senior awards of the Department of Scientific and Industrial Research and other fellowships of similar status have

also assisted, but the number of these alone would have been quite inadequate.

The main object of the scheme is being amply fulfilled in the much enhanced output of research at the universities; but an important subsidiary effect has been the establishment of a reserve of potential lecturers of high calibre from which the universities have drawn freely in making new appointments to their staffs. Analysis of data supplied by the universities to the Inter-University Consultative Committee set up to administer the scheme disclosed that 70 per cent of the eighty Fellows who had relinquished their fellowships during the first five years of the scheme had been appointed to university teaching posts. Eight of these now hold professorial chairs and five are now readers in universities in Britain, the Dominions and the United States. Only a small number of former Fellows have taken industrial posts: the remainder of former Fellows have mostly joined the staffs of Government research establishments and of such research institutes as the Lister Institute, the Rowett Research Institute and the Long Ashton Research Station.

In extending the research fellowships scheme for another seven years, the directors of Imperial Chemical Industries, Ltd., have raised the normal value of each fellowship to £800, with power to vary the amount between £600 and £900. Four fellowships tenable in the University of Wales have been added, bringing the total, with the six fellowships at Leeds added in 1945, to ninety fellowships in eleven British universities at an annual cost of £72,000. The fellowships are tenable in chemistry or physics or in an allied science which has some direct relation to the manufacturing interests of Imperial Chemical Industries, Ltd. While this is interpreted in no narrow spirit and is a reasonable requirement from the point of view of shareholders, it has the further advantage of facilitating expansion at the new growing-points of science. It was one of the original hopes of the scheme that it would be used by the universities to redress the balance of research. During the past year, for example, fellowships have been held in biochemistry, chemotherapy, pharmacology, metallurgy, the various branches of engineering, geology and applied mathematics as well as in chemistry and in physics. The working of the scheme is entirely in the hands of the universities, although for convenience they have agreed on certain broad principles of administration.

Although this is much the largest scheme in Britain of its kind, it does not cover all the universities. Fellowships of a similar character have been established by Turner and Newall in the Universities of Durham, Leeds, London and Manchester, by the Bradford Dyers Association at Leeds, by J. and P. Coats, Ltd., at Glasgow and by the Pressed Steel Fellowship Co., Ltd., at Oxford. There are other fellowship schemes endowed by Courtaulds, Monsanto and the Glaxo Laboratories, and when we take account of those established at King's College, Newcastle upon Tyne, by the British Coke Research Association and the North East Coast Institution of Engineers and Shipbuilders, and of the support given by the Nuffield Foundation to research programmes in many universities, it seems clear that voluntary action is still making an important contribution to the preservation of the independence of the universities in times of increasing reliance on support by the State. How long fiscal conditions or financial policy will permit the continuance of voluntary aid on such a scale is unfortunately far from certain. At least it can be said that, for the present, initiative in Great Britain has found a most hopeful way of dealing with a problem which is arousing equal concern in the United States and in Switzerland, if not elsewhere.

INDUSTRIAL RESEARCH IN ELECTRONICS

Electron Tubes

Edited by Alfred N. Goldsmith, Arthur F. Van Dyck, Robert S. Burnap, Edward T. Dickey and George M. K. Baker. Vol. 1 (1935–1941). Pp. x+475. Vol. 2 (1942–1948). Pp. x+454. (Princeton, N.J.: Radio Corporation of America, 1949.) 2.50 dollars each volume.

Data and Circuits of Receiver and Amplifier Valves, 1933–39

Translated by G. Ducloux. (Philips Technical Library: Book 2.) Pp. xii+409. 21*s*. First Supplement, 1940–41. (Philips Technical Library: Book 3.) Pp. x+212. 12*s*. 6*d*.

Application of the Electronic Valve in Radio Receivers and Amplifiers

By Dr. B. G. Dammers, J. Haantjes, J. Otte and H. van Suchtelen. Translated by S. H. Alexander. (Philips Technical Library: Book 4.) Pp. xxiv+416. 35*s*.

(Eindhoven: Philips' Gloeilampenfabrieken; London: Cleaver-Hume Press, Ltd., 1949–50.)

IN the middle thirties the Radio Corporation of America began to reprint collections of papers written by its engineers, which had appeared in the *R.C.A. Review* and other periodicals. Several of these collections have now been published, dealing with television and frequency-modulation radio. The latest volumes are devoted to vacuum tubes, Vol. 1 of "Electron Tubes" containing papers originally published between 1935 and 1941, and Vol. 2 covering the years 1942–48. The usefulness of such re-publication naturally depends on whether or not the papers represent a lasting contribution to scientific research, and it is clear that the editors have made a serious attempt to confine themselves to such material, less-important papers which still have some general interest being presented in summarized form.

By far the most important work in Vol. 1 is the group of five papers on fluctuations in space-charge-limited currents at moderately high frequencies, by B. J. Thompson, D. O. North and W. A. Harris. These papers appeared in the *R.C.A. Review* in 1940 and 1941, and are therefore not as freely available in Great Britain as they should be. The core of the work is the paper in which North calculates the influence of space-charge smoothing on the shot noise in diodes and negative-grid triodes. The calculation is made by considering that the number of electrons

in each velocity class is subject to a pure shot-noise fluctuation and by numerical evaluation of the smoothing effect due to the potential minimum, using the Fry–Langmuir solution for the diode with initial velocities. North obtains the now well-known result that the electron current fluctuations in a space-charge-limited diode produce the same mean-square noise voltage as would be produced by a resistance equal to the slope resistance of the valve the temperature of which is two-thirds of the cathode temperature. This result was obtained in 1936, before the rather similar calculations of W. Schottky and E. Spenke and A. J. Rack were published. None of these calculations is particularly easy to follow from the physical point of view, and it is only during the past few years that an improved understanding of the behaviour of electron beams at very high frequencies has led to a good physical model for the process. Unfortunately, the contributions of North and W. R. Ferris to the theory of valves at ultra-high frequencies are only included in the summaries. The papers on noise take up about 130 pages, and the book is well worth buying for these alone. Other papers worthy of mention are L. Malter's account of thin-film field emission ('Malter effect'), V. K. Zworykin on secondary-emission multipliers, and G. A. Morton and E. G. Ramberg on the electron optics of image tubes. The sections on transmitting and receiving tubes are less interesting, as the passage of time has removed a good deal of their relevance.

In Vol. 2 the general selection includes a study of induction acceleration by J. A. Rajchmann and W. H. Cherry, papers on the travelling-wave tube (C. I. Shulman and M. S. Heagy) and on the two-beam growing-wave tube by L. S. Nergaard. In the field of picture converters there are accounts of the infra-red image tube developed during the Second World War for night sniping and driving (G. A. Morton and L. E. Flory), and of the development of a barrier-grid storage tube capable of storing a complete radar plan-position-indicator (P.P.I.) picture for a very considerable period of time (A. S. Jensen, J. P. Smith, M. H. Mesner and L. E. Flory). A notable omission from this volume is a full account of the large amount of work carried out by the Radio Corporation of America on frequency modulation of magnetron oscillators by passing subsidiary electron beams through the resonant cavities. None of the papers on this subject is considered worth more than a summary, and the fundamental theoretical paper by L. P. Smith and C. I. Shulman is not even summarized. This volume is not nearly as successful as the first; the accounts of recently developed tube types are purely theoretical and do not bear the marks of a rigorous comparison with experiment. The exception is, of course, in the field of picture transmission, where the Corporation has concentrated so much effort in recent years.

Both books are durably bound, and the printing, presumably by a photographic process, is nearly always good; but the reproduction of many of the photographs is distinctly poor, and in some illustrations of valve parts or sub-assemblies it is practically impossible to see the features commented on in the text (for example, Vol. 2, p. 201, Fig. 4). Both volumes contain additional bibliographies relating to publications by staff members of the Radio Corporation of America. It would be more useful for reference purposes to include a bibliography of work in the same field by authors not in the Corporation, but this is perhaps asking too much. Most professional valve engineers will wish to have these books at hand, and it is gratifying that their price is very reasonable.

The Philips Company, of Eindhoven, is following the example set by the Radio Corporation of America, the other three books under review being Books 2, 3 and 4 of the Philips Technical Library Series on electronic valves. The first two are valve data handbooks covering the valves issued in Holland during 1933–39 and 1940–41 respectively. In addition to the parameters and characteristic curves there are fairly extensive application notes, particularly for types with unusual features, for example, the *EE*50 secondary-emission multiplier. Many of the valves are obsolete, and many of the types still made are only known in Great Britain with different bases. These volumes are of little general interest. A further volume covering 1945–50 is in preparation.

Book 4 is the first part of a trilogy devoted to the theory and design of receivers for broadcast transmissions, not including television or frequency-modulation radio. This part deals with high- and intermediate-frequency amplifiers, frequency changing, the padding of superheterodyne receivers, radio-frequency interference and the performance of the second detector. The discussion is complete and exhaustive within the bounds of the authors' programme, and is fairly mathematical in tone. The treatment of distortion due to curvature of valve characteristics, and that of high- and low-level detection, is particularly exhaustive. A feature which is unusual in technical literature on radio is that economic aspects of design are often discussed. The book seems rather old-fashioned to anyone familiar with modern British and American radio techniques; but this is simply because so many subjects which must be included when frequencies above 40 Mc./s. are considered are, quite properly, regarded by the authors as outside their field. I found the brief treatment of transit-time effects far from clear. The lists of references at the end of each chapter should be much more extensive. Printing and binding are excellent, and one is rarely conscious that the work is a translation. This book may well prove to be the definitive work on the design of broadcast receivers.

A. H. W. Beck

THEY ARE NOT MARXISTS

In Defence of Philosophy

Against Positivism and Pragmatism. By Maurice Cornforth. Pp. xv+260. (London: Lawrence and Wishart, Ltd., 1950.) 12*s.* 6*d.* net.

MEN talk and think, according to Mr. Maurice Cornforth, because they make and use tools in order to live; and their thinking, if it is to guide their actions successfully, must reflect real features of the world. The real world is, however, at any epoch reflected in thought through conceptions which depend on the structure of their economic social life.

It is from this point of view that he examines various exponents of logical positivism and of pragmatism. One would expect him to find them congenial, for many of their views are close to his own. For example, they all agree that we cannot test our knowledge by comparing our ideas directly with things. They link knowing closely with experimenting, which is a practical activity of a special

sort; and they all agree that scientific concepts at any epoch are relative and not final.

But all this is not enough. For logical positivists reject as unverifiable, and therefore meaningless, the statement that there is a world independent of all knowers; while the pragmatists deny that successful practice is a guarantee that the thinking which guides it must, in order to do so, reflect real features of an independent world. This then is the author's main complaint.

Mr. Cornforth's second complaint is even graver: namely, that in their account of the formation, development and modification of scientific concepts, both logical positivists and pragmatists neglect the influence of the basic processes of human social economic productive activity. This complaint runs "like a red thread" through the whole of the book; and it gives emotional colour to his first complaint. By "divorcing conceptual thinking from the basic processes of human social production" (he says this about Dewey, but it expresses his view about the others as well) and by denying that science can give knowledge of objective reality, they are turning away from the real conditions of modern social life, and evading the real problems of science, that of helping the masses to escape from their exploitation by the capitalists. He goes further, and claims that their views are an expression of the capitalist outlook, the confusions and self-contradictions which he finds in them mirroring the confusions and self-contradictions of capitalism itself.

The evidence Mr. Cornforth brings for this conclusion seems quite inadequate. However, he writes with clarity, sincerity and candour, and he has great intellectual ability. Though his treatment often results in a distortion of the views he is criticizing, he puts his readers in a position to judge for themselves whether it does so or not. There are many gaps in his presentation of his own views, but he does not try to cover them up, and these are great merits.

The survey is wide, and refers to most of the important writers, Carnap and Dewey being the ones studied at greatest length; and the book may be recommended as a stimulating and provocative commentary, to anyone who is willing to go to the sources for himself. The chapters on dialectical materialism, and on materialism versus idealism, may be commended as an admirable introduction to Marxist philosophy.

L. J. Russell

BRITISH SCIENCE AND TECHNOLOGY SINCE 1851

A Century of Science, 1851–1951
Written by Specialist Authors under the editorship of Prof. Herbert Dingle. Pp. 338. 15*s*. net.

A Century of Technology, 1851–1951
Written by Specialist Authors under the Editorship of Dr. Percy Dunsheath. Pp. 346+20 plates. 15*s*. net.
(London: Hutchinson's Scientific and Technical Publications, 1951.)

THESE two books purport to trace the development of science and of technology during the past hundred years, and to contrast the general position of various branches at the time of the Great Exhibition of 1851 and to-day. They are largely complementary, but there is some technology in the volume on science and much science in that on technology, and to some extent this is due to the divisions adopted.

This is particularly so in "A Century of Science", and moreover it includes at least two chapters—those on medicine, surgery and their scientific development, and on medical psychology—which could well be regarded as properly belonging to technology. The book includes chapters on the concept of energy, structure of the atom, field physics, particle physics and geology. Prof. J. R. Partington deals with both the structure of molecules and the chemical elements, organic chemistry being discussed in little more than two pages of his second chapter. A chapter on the atmosphere of the earth is followed by one on the constitution and evolution of stars and another on the structure of the universe. Besides chapters on organic evolution, on the coming of man, on the progress of *Homo sapiens*, and on genetics and embryology, there are others on physiology and histology and on biochemistry, as well as on general psychology, and an essay by the editor, Prof. H. Dingle, on the significance of science.

The balance of the book is open to criticism, and this can also be said of the contents of individual chapters. Chemotherapy is inadequately treated in the chapter on medicine and surgery, particularly in comparison with the space given to medical psychology and general psychology. Nor is the balance redressed in "A Century of Technology". Although that volume contains a chapter on biochemical industries in which due emphasis is placed on achievements in the development of antibiotics, only the briefest reference is made to medicinals in Dr. T. I. Williams's chapter on heavy and fine chemicals. Indeed, the cursory treatment of organic chemistry in the volume on science is paralleled by that given to organic chemical industry in the volume on technology; no one could gather from either book any idea of the way in which the flowering of organic chemistry in the second half of the nineteenth century led to the development of a great organic chemical industry. The achievements of the dyestuffs industry are indicated more in passing by Dr. D. W. Hill in his chapter on textiles than by Dr. Williams, nor, save in the chapter on petroleum technology, do we get a hint of the importance of petroleum as a source of organic chemicals; again, there are no indications of the new importance of acetylene. In any reprint, "Heinrich" should be corrected to "Peter" Griess.

With such reservations, "A Century of Technology" covers technological developments reasonably well, although the emphasis is largely on developments in engineering, and in applied physics it gives a very readable account of many of the outstanding developments of the past hundred years. A well-informed scientist and technologist may find both books useful in giving a ready perspective of the development since 1851 of both science and technology. It is not, however, easy to decide for whom the books are intended. Both, but especially that on science, seem to assume a knowledge of science and mathematics which the general reader is unlikely to possess. As a contribution to the Festival of Britain, something simpler, better balanced and more carefully planned is required to convey to a general reader a true appreciation of developments in either science or technology, and more especially of the British contribution to such developments.

R. Brightman

DEVELOPMENTS IN ASTRONOMY

A Concise History of Astronomy

By Peter Doig. Pp. xi+320. (London : Chapman and Hall, Ltd., 1950.) 21*s.* net.

THE writer of a concise history of astronomy is often confronted by the difficulty of deciding on the amount of space that should be devoted to various developments in the subject. Maintaining a true sense of proportions is not always easy, and an author is often open to the accusation that he has bestowed too much attention to some minor developments while other branches have been dismissed with scant consideration. Very few readers can make this charge against Mr. Peter Doig's book—the first of its kind which has appeared in Great Britain for forty years, though, by a remarkable coincidence, Abetti's "Storia dell'Astronomia", recently published in Italy, runs on parallel lines to the work under consideration.

The first four chapters are devoted to the astronomy of the Chinese, Egyptians, Babylonians, Indians, Greeks, Mohammedans and Tartars ; and, as these chapters cover less than one-sixth of the whole book, sufficient space is left to deal with modern developments which, to most readers, are the matters of primary importance. The volume is much more than a history of the lives of those who have made outstanding contributions to astronomy, though this part has not been neglected ; it provides also a history of the development of ideas, theories and instrumental equipment, and it is certain that the author's hope, expressed in the preface, that it will be "a handy reference book useful to students as a record of the main events and of the chief work of individual astronomers", will be fulfilled. A bibliography of useful books and various astronomical periodicals, at the end of the chapters and on pp. 310–11, and also an index, enhance the value of the work. In connexion with the index, one wonders whether it would not have been better to have divided it into names and subjects ; the former occupy by far the greater portion of the index and are very comprehensive (but why has Lyttleton's name been overlooked, though mentioned on p. 254 ?), but in some cases references to certain subjects have been omitted. As an example, although "Stellar Populations" and "Distribution of Galaxies in Space" appear as headings on p. 306, there is no reference to them in the index.

It is practically certain that a second edition will appear, and if so the following suggestions might be worth noticing. Readers might be led to believe from reading p. 134 that the sole responsibility for Leverrier's credit to priority in predicting the place of Neptune devolved on Airy ; but, as the Astronomer Royal pointed out a few years ago[1], the fault was largely due to Adams, who failed to reply to a letter from Airy, an omission for which he apologized in later years. On p. 246 the diameter of Pluto is given as about the same as that of the earth, but Kuiper's measurement a year ago showed that it is less than half that of the earth. The announcement was, however, probably too late to be included in the book. On p. 251 no reference is made to the work of Lovell and his colleagues on meteor velocities. Lovell has stated that "at present the radio measurements strengthen the case of those who believe that all meteors—sporadic or in showers—are members of the solar system". This supports the view of Porter on the elliptical motion of meteors.

All these, however, are very trivial matters and do not detract from the value of the book, which has obviously been compiled with considerable care.

M. DAVIDSON

[1] "John Couch Adams and the Discovery of Neptune" (Cambridge University Press, 1947).

DESIGN OF ELECTRICAL INDUCTORS

The Theory and Design of Inductance Coils

By Dr. V. G. Welsby. Pp. 180. (London : Macdonald and Co. (Publishers), Ltd., 1950.) 18*s.* net.

DR. V. G. WELSBY'S book presents features of the subject which although well represented in scientific papers have, so far, found little place in British text-books. His aim is to develop the basic design principles of inductors, with and without ferromagnetic cores, and to cover the whole frequency range from power to radio frequencies. There are, therefore, three main divisions of the subject, namely, air-cored coils, coils with laminated iron cores and coils with dust cores. Two chapters deal with the basic theoretical considerations—the equivalent circuits of inductance coils, the effects of self-capacitance, and skin and proximity effects. Ferromagnetic phenomena, magnetic circuit concepts and their limitations, and mathematical analysis applied to hysteresis and eddy-current effects constitute the contents of another chapter, and a further chapter is devoted to harmonic distortion in iron-cored coils.

The telecommunications engineer expresses the 'goodness' of a coil in terms of its '*Q* factor', that is, the ratio of its reactance to its resistance, and it is on this basis that the analysis of coil performance and the theory of coil design are developed. A method of graphical analysis devised by Dr. Welsby for use in coil design is the subject of one chapter.

It might be thought that a book of less than two hundred pages attempting to deal with a subject of such wide scope must necessarily be superficial, and to a certain extent this criticism could be sustained ; but the author has achieved a remarkably successful compromise by restricting his attention to the ranges of parameters which are of practical importance and by specifying the ranges within which formulæ and approximations are valid. He has collected and presented in a systematic fashion the essential basic matter of a very large part of the available information on inductor design. In my opinion one chapter of the book, that on impedance measurement, might preferably have been omitted and the space utilized to accommodate material more directly related to the design problem. For example, the important topic of spiral cores and the characteristics of joints in laminated cores might have received attention. Again, in a book of this type in which it is possible to deal only with salient features and in which simplifying assumptions and approximations abound, a much more extensive bibliography would have been appropriate.

This book is a useful work of reference for the designer of inductors whether he be concerned with telecommunications or with the 'lighter' branches of power engineering.

J. GREIG

Elsevier's Encyclopædia of Organic Chemistry

Edited by F. Radt. Series 3: Carboisocyclic Condensed Compounds, Vol. 12B: Naphthalene, A, Compounds containing One Naphthalene Nucleus, Hydroxy Compounds. Pp. xxxix+1053–2187+Ind. 108. (New York and Amsterdam: Elsevier Publishing Co., Inc.; London: Cleaver-Hume Press, Inc., 1950.) £29 to subscribers to whole work.

THIS volume follows the pattern of earlier volumes of Elsevier's Encyclopædia (see *Nature*, **161**, 415 (1948); **163**, 822 (1949); **166**, 244 (1950)). It is the third part of Vol. 12B, dealing with naphthalene and its derivatives, and is concerned with all classes of hydroxy compounds related to naphthalene and the hydronaphthalenes. Although with this part Vol. 12B reaches a total of 2,187 pages, with indexes, it is not yet complete. When it is, it will be the reference work *par excellence* for those interested in the chemistry of naphthalene derivatives.

There are comprehensive accounts of the chemistry of the naphthols and their various reduction products, together with di- and poly-hydroxy naphthalenes, and also various derivatives of naphthalene and hydronaphthalenes in which one or more hydroxyl groups are present in side-chains. The halogenated naphthols, the nitronaphthols, the aminonaphthols and the azonaphthols are also dealt with, together with multifunctional compounds of these types and homologues of all of them. Scattered through the book are entries relating to alcohols of the sesquiterpene, diterpene and triterpene series (for example, eudesmol, cadinol, manool, sclareol, ambrein) having reduced naphthalene systems in their molecules, and it is interesting to note that the substances treated in the section which precedes the naphthols proper include the dyestuffs victoria blue and night blue.

The absence of references to the patent literature will naturally limit the usefulness of the work for those who are primarily interested in dyestuffs prepared from the naphthols and their derivatives. In technical production and freedom from error, this volume maintains the high standard of its predecessors.

J. W. Cook

Mechanics and Properties of Matter

By Dr. R. C. Brown. Pp. ix+276+ix. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1950.) 10*s*. 6*d*.

IN this book, the first volume of a series intended to cover the various branches of physics up to school advanced and university intermediate level, the author's first consideration has been to make the fundamental principles clear to the average student. A university teacher and examiner of Dr. R. C. Brown's experience must realize all too well the chinks (a courtesy term) in the student's armour, where derivation of formulæ so often takes the place of trusty proof. His wise statement that mathematical analysis is not necessarily a substitute for physical reasoning indicates the general approach, which I find admirable.

Perhaps the conventional treatment of mechanics has formed itself around the mental habits of students, who tend at this level to prefer learning rules to thinking about principles. Will Dr. Brown convince and convert them? There can be little doubt about this when one turns to the chapters on circular motion, Newton's laws of motion, and the dynamics of simple systems, and realizes that these are really thorough pieces of explanation, set out in the simplest terms yet shirking no important point. The chapter on surface tension is, as would be expected, excellent, and those on fluids in motion and diffusion and osmosis, though short, contain all that the student will need. Altogether, it is a very useful book which incorporates a good deal of training and much sound teaching in its presentation of the work.

G. R. Noakes

Surface Active Agents

Their Chemistry and Technology. By Anthony M. Schwartz and James W. Perry. Pp. xi+579. (New York and London: Interscience Publishers, Inc., 1949.) 60*s*.

ALL interested in surface-active agents and their varied applications will welcome this book; its value is greatly enhanced by the numerous references given. In Part 1 the authors deal very thoroughly with the preparation of surface-active agents, and, although such agents exist in great number, the subject remains clear as a result of their convenient grouping into anionic, cationic, ampholytic and non-ionic types. Part 2 of the book describes the physico-chemical techniques used for investigating the properties of these agents in bulk aqueous phase. Wetting, foaming, emulsification and detergency are described with reference to up-to-date literature. In Part 3 applications of surface-active agents are comprehensively reviewed, and the patent literature given here is extremely useful for those directly interested in industrial application.

The authors have assembled in a very satisfactory manner the present knowledge of surface-active agents, and, although this branch of chemistry is expanding rapidly, their book will be much appreciated by all workers in the field and will stimulate the interest of students.

R. Matalon

La plongée en scaphandre

Par Commandant Tailliez, Commandant Cousteau, Lieut. Alinat, Dr. Devilla et F. Dumas. Pp. 120+7 plates. (Paris: Éditions Elzévir, 1949.) n.p.

IN this book the authors lead the reader through the physics, physiology and material aspects of diving, including standard and self-contained apparatus and mixture breathing. In fact, in a volume of this size, they have attempted to cover too much ground. The result is a book which, while being difficult for the beginner, is elementary to the expert. New decompression tables, based on those in use in the United States, have been recalculated in metres. It is interesting to note that the authors take into account the '120-minute tissue'. Recent experiments in Great Britain have shown that the '75-minute tissue' is probably the longest. The method of computing a 'combined dive' is novel and simpler than that in use in Britain. The book, apart from some mistakes in spelling and in the calculations, is well printed and has some excellent illustrations.

Laboratory and Workshop Notes

A Selection reprinted from the *Journal of Scientific Instruments*. Compiled and edited by Dr. Ruth Lang. Pp. xii+272. (London: Edward Arnold and Co., 1949.) 21*s*. net.

ANY work sponsored by the Institute of Physics must command attention, and this collection of laboratory and workshop notes taken from the *Journal of Scientific Instruments*, for the production of which the Board of the Institute is responsible, is no exception. The book is not intended to cover the complete range of laboratory and workshop practice, but all the problems dealt with are extremely useful

to everyone engaged in science work and instruction. The entire collection is divided into eight sections, covering the whole range of physical topics. This division is admitted to be an arbitrary one, as is, indeed, the complete collection, and it must have been difficult for the compiler to know which to include and which to omit.

It would be invidious to pick out any device or experiment or section for special mention, but certainly the sections dealing with tools, etc., and with soldering, etc., should appeal strongly to those who have to 'make-do and mend' in the laboratory. A further selection of notes is promised if the present volume receives a favourable reception; it is to be hoped that this will be the case, for the volume deserves to be widely known and used.

Spotlight on Animals

By Chapman Pincher. With Illustrations by Eric Tansley. Pp. 188. (London: Hutchinson and Co. (Publishers), Ltd., 1950.) 12*s*. 6*d*. net.

THIS fascinating book by the scientific correspondent of a national daily newspaper with a wide circulation is chiefly remarkable for the surprising variety of subjects which are considered. These include the habits of bees, the taking of a whale's temperature, the intelligence of sheep and animal borers in wood and rock. Each essay shows real evidence that Chapman Pincher has gone to original sources for his material, and in every way shows the authoritative nature of his writing. The author is to be commended for his gift of making sometimes difficult topics intelligible to the general reader; although, in some places, the attempt to avoid teleology has led to a staccato effect which makes for disconnected reading and is in sharp contrast to the more fluid style of writing which Pincher generally provides. The value of the book is considerably enhanced by sixteen scraper-board drawings which have been contributed by Eric Tansley. Some of these, and notably one of a chimpanzee, are exceptionally good.

Audubon's Birds of America

Introduction and Descriptive Captions by Ludlow Griscom. Popular edition. Pp. 320 (288 plates). (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1950.) 22*s*. net.

AUDUBON'S bird portraits have to modern eyes a formality that makes them appear somewhat stiff. One can say the same of Gould. Yet there is a fascination about their work that none can gainsay, and for truth of delineation they are hard to surpass. French by birth but belonging to the United States by settlement and devotion, Audubon's ambition was to publish a series of paintings of all the birds of North America, and he realized it, producing his monumental work in about twenty-five years at a vast expense of time, energy and labour.

The task was completed by 1838 and less than two hundred sets were published at 1,000 dollars each; in short, this amazing production was definitely out of reach of the average ornithologist. In recent years a number of Audubon books have been published in an effort to bring his genius within reach of 'the man in the street'; and now there is this popular edition of the "Birds of America", at 22*s*., with an introduction by Ludlow Griscom, which shows 288 of the pictures reproduced in colour, and gives all a chance to view and appreciate the skill of this remarkable man.

The very formality already remarked upon enhances the decorative aspect, and each picture is a masterpiece of design; however, the ornithologist will survey them from the portrait point of view, and again they are amazingly satisfying. The character of each species has been captured, in addition to accuracy of feather detail—witness the last plate of the snow bunting. This book enhances one's respect for the memory of a great bird artist.

FRANCES PITT

Elementary Forestry

A First Textbook for Forest Rangers. By Dr. W. J. Eggeling. Revised by R. G. Sangster. (Baillière's Elementary Tropical Handbooks.) Second edition. Pp. xvi+307. (London: Baillière, Tindall and Cox, 1949.) 6*s*. net.

THE preparation and publication of elementary tropical handbooks as text-books for use of the English-speaking staffs in the non-commissioned ranks of the government departments has proved of great value. Of this type are Baillière's handbooks, of which one, "A First Textbook for Forest Rangers", by Dr. W. J. Eggeling, conservator of forests, Uganda, was first published in 1942, with a second edition in 1949. For this latter edition the author had the collaboration of the staff of his department. These handbooks are intended to be accompanied by tuition; they are simply written so that they can be used by those whose knowledge of English is too limited to enable them to use standard English text-books. In this lies their great value.

The danger inherent in such publications, as also in laying down the standard of tuition in schools for rangers or foresters schools, is the standard upon which they are drawn up, the course outlined, and what is meant by the word 'elementary'; in other words, in the case of forestry, the problem is how far advanced in the various branches is the student of such courses. In the treatment of this book, the first six chapters are devoted to forestry, soil, simple botany, demarcation and survey, protection, management and exploitation. Chapters 8–10—regeneration; nursery work; formation, tending, etc., respectively—form an introduction to sylviculture; if the lecture course is given as in this book, to postpone the chapters on sylviculture from their natural position following Chapter 3 would appear to indicate that they had no close connexion with the first three chapters. It may be suggested that some slight rearrangement of chapters might receive consideration in the next edition of what is a valuable little book.

Scientific Autobiography and other Papers

By Max Planck. With a Memorial Address on Max Planck, by Max von Laue. Translated from the German by Frank Gaynor. Pp. 192. (London: Williams and Norgate, Ltd., 1950.) 8*s*. 6*d*. net.

THIS volume, which is a translation of part of a German publication, contains an autobiography and papers based on popular lectures on phantom problems in science, the meaning and limits of exact science, the concept of causality in physics, and religion and natural science. Although everything written by Planck is interesting and worthy of study, the papers here collected do not represent his best work, and the philosophical ideas proposed are now somewhat outdistanced. The translation is not very good, either in style or accuracy.

J. R. P.

BRITAIN'S SCIENTIFIC SHRINES (3)

By Eng.-Captain EDGAR C. SMITH, O.B.E., R.N.

THE SOUTH-WESTERN COUNTIES

HAVING covered the seven counties lying between the Thames and the Channel, from the county of Wiltshire the survey is now carried into the adjacent counties of Gloucestershire and Somerset and from these to the Lizard, near which is the Marconi memorial given to the National Trust in 1937. Here stood the world's first high-power wireless transmitting station, from which on December 12, 1901, signals were sent which were heard by Marconi himself in Newfoundland.

The district now to be covered might well be called Brunel's country, for it is most easily traversed by the old Great Western Railway, which a writer in 1839 described as "by far the most gigantic work of the kind, not only in Great Britain, not only in Europe, but we venture to say, in the whole world". The headquarters of the railway company were at Bristol, and it was there that in 1833 Brunel, then but twenty-seven, was appointed engineer of the line. It was also from Bristol that Brunel's *Great Western* sailed in 1838 for New York; it was at Bristol in 1843 that Prince Albert watched the floating of the iron screw-ship *Great Britain*, and to-day the Avon gorge is crossed by the suspension bridge which, built to Brunel's design, originally spanned the Thames at the site of the Festival of Britain Exhibition. Gloucester, Bath, Taunton, Exeter, Torquay, Plymouth, Falmouth and Penzance are all reached by the same railway, the last link in which was closed when Prince Albert on May 2, 1859, opened the Royal Albert Bridge over the River Tamar, which bears on its portal in large letters 'I. K. BRUNEL'. His broad-gauge track and rolling stock have long since disappeared, his many great timber viaducts have all been replaced, his *Great Britain* rests in a cove in the Falkland Islands; but so long as the railway itself exists, Brunel has little need of other memorial. Born at Portsmouth in 1806, he died on September 15, 1859, and like his famous father was buried in Kensal Green Cemetery, London. A window was erected to his memory in Westminster Abbey, but it is no longer in place.

Of the scientific worthies of Gloucestershire, one of the earliest and most famous was James Bradley (1693–1762), the Astronomer Royal. Born at Sherborne in the north-east of the county, he was educated at Northleach Grammar School, and after his fruitful years at Oxford, Wanstead and Greenwich, he returned to his native county, dying at Chalford and being buried at Minchinhampton. In the church there can be seen the brass which once was on his tomb in the churchyard, but was stolen and then recovered. Next in point of time came John Canton (1718–72), son of a Stroud weaver, who became a London schoolmaster and twice received the Copley Medal of the Royal Society, first in 1751 for making artificial magnets, and then in 1764 for proving the compressibility of water. It is no great distance from Stroud to the city of Gloucester or the village of Berkeley. In Gloucester Cathedral stands the statue of Edward Jenner (1749–1823), while at Berkeley can be seen the vicarage in which he was born, the church in the chancel of which he is buried, and in the vicarage garden the hut in which on May 14, 1796, he inoculated a boy of eight with cowpox. He made known his discovery of vaccination as soon as he was convinced of its value and sought no reward, but a grateful nation granted him £10,000 in 1802 and in 1807 a further sum of £20,000.

About thirty years after the birth of Jenner, Henry Kater (1777–1835), the physicist who became known for his pendulum experiments, was born at Bristol, and twenty-five years later, Charles Wheatstone (1802–75) was born at Barnwood, two miles from Gloucester. The son of a musical instrument maker, he was placed with an uncle in London, and at the age of thirty-two he was made professor of experimental philosophy at King's College, London, where in conjunction with W. F. Cooke he developed his electric telegraph. Like Bradley and Canton, he was a Copley Medallist, and like Brunel was buried at Kensal Green. A Bristolian writing of her men of science could say much of Davy and others, and also of the growth of the University of Bristol, the story of the early fortunes of which is contained in the "Life" of Sir William Ramsay.

By rail a traveller from London comes to Bath, in Somerset, before Bristol, in Gloucestershire, and he may well set out from Bath to explore Somerset, Devon and Cornwall. Bath is essentially an eighteenth century city, and it was in the early days of her famous arbiter of fashion, Beau Nash, that the mathematician, Benjamin Robins (1707–51), was born. The son of a Bath Quaker, he abandoned the tenets of his sect and became the foremost authority of his day on the art of gunnery, and after a life of varied activities died in Madras when engineer-in-chief to the East India Company. About sixty years after the birth of Robins, when the slopes of Bath were being covered by splendid terraces and crescents, William Herschel (1738–1822) came to the city from Halifax to be organist at the Octagon Chapel, making a great reputation, not by music, but by the fashioning of telescopes and the discovery of Uranus. To Bath also came the traveller and botanist John Sibthorp (1758–96), but only to die. He had held the chair of botany at Oxford and left money for founding a chair of rural economy. A charming piece of sculpture in Bath Abbey by Flaxman perpetuates his name. When Sibthorp died, the Bath district was the scene of the labours of a still more distinguished naturalist, William Smith (1769–1839), 'Strata' Smith, the 'father of English geology'. Born in Oxfordshire and trained in surveying, he came to the south-west of England to be engineer of the Somerset Coal Canal, making his sojourn memorable by his discovery of the fundamental principles of geological stratification. He died at Northampton, and his monument is in St. Peter's Church there. To commemorate the centenary of his death, the Geologists' Association during March 21–26, 1940, held a field-meeting in the Bath district. An illustrated account of their pilgrimages to the homes and haunts of Smith is given in vol. 52 of the *Proceedings* of the Association, where a reference is made to the tablet on 29 Great Pulteney Street, Bath, erected by the City Corporation in 1926.

From Bath to the county town of Taunton is about an hour's run by train, and in the Taunton Shire Hall are memorials to many Somerset worthies, among whom was Thomas Young, who spent the early years of his precocious childhood at his father's Quaker home at Milverton, to the west of Taunton. Somerset's oldest scientific worthy, however, is Roger Bacon (1214–94), who has been called "the champion of unfettered enquiry in an age of scientific stagnation". His birthplace was the village of Ilchester in the south-east of the county. When, to commemorate the seven hundredth anniversary of Bacon's birth, Oxford erected a statue to him, "a few admirers of his genius" placed a brass tablet in Ilchester church. Somewhat nearer Taunton, but still to the south, lies the town of Chard, familiar to every student of aeronautical lore as the scene of the experiments made during 1843–47 by W. S. Henson (1805–88) and John Stringfellow (1799–1883), parts of whose steam-driven model aeroplanes are preserved in the Science Museum, London. Neither Henson nor Stringfellow was a Somerset man, for the former came from Leicestershire and the latter from Yorkshire.

There are many families several members of whom have distinguished themselves as investigators, and in the chronicles of science in Devonshire a prominent place must be given to the Mudge family, of whom no fewer than eight are mentioned in the "Dictionary of National Biography". The first of the group was Zachariah Mudge (1694–1769), schoolmaster and divine, friend of Johnson, Burke and Reynolds. When the Eddystone Lighthouse was completed, Smeaton took him into the lantern of the tower and there together they sang the "Old Hundredth". Of his descendants, his sons Thomas Mudge (1717–94) and John Mudge (1721–93) were known either for their chronometers or telescopes, while his grandson William Mudge (1762–1820) and a great-grandson Richard Mudge (1790–1854) were both soldiers and geodicists. The story of the family takes the reader to Exeter, Bideford and Plymouth, and it was in the now ruined church of St. Andrew's, Plymouth, that Zachariah and John Mudge were buried. Zachariah was a native of Exeter, a city which in 1845 gave to science the brilliant but short-lived mathematician William Kingdon Clifford (1845–79), of University College, London.

From Exeter those interested in astronomy can find something to their taste at the seaside resort of Sidmouth, where Sir Norman Lockyer (1836–1920), the founder and first editor of *Nature*, on his retirement set up the Salcombe Hill Observatory. In 1922, Sir Frank Dyson unveiled a portrait medallion to him in the Observatory, where another memorial commemorates his son, Dr. W. J. S. Lockyer (1868–1936), who succeeded his father as director. To-day the work of the Norman Lockyer Observatory is carried on as a department of the University College of the South-West, Exeter.

Resuming the journey by rail from Exeter to Torquay and Plymouth, the traveller passes over a section of line on which Brunel experimented unsuccessfully with the atmospheric system of propulsion, and there are possibly portions of the pumping stations still standing. Torquay is reached by a branch-line from Newton Abbot. Foremost among the naturalists of Torquay was William Pengelly (1812–94), in whose memory a hall was added to the local museum. Another notable man associated with Torquay was William Froude (1810–79), who at Chelston Cross, with Admiralty assistance, erected the first experimental tank for studying the resistance of ships, and in so doing made an epoch in naval architecture. Froude was born at Dartington, on the River Dart, but lies in the naval cemetery at Simonstown, South Africa. In more recent times, Torquay has been a centre of interest for electricians, for here Oliver Heaviside (1850–1925) passed the later part of his somewhat lonely life, writing those mathematical and physical papers which made him known among the most learned of his fellows. After his death he was laid in his father's grave in Paignton Churchyard. To mark the centenary of his birth, the Institution of Electrical Engineers last year held a special gathering and published a memorial volume.

Few visitors to Torquay miss enjoying the beauties of the Dart, or fail to cross to Dartmouth, the site of the Royal Naval College. Dartmouth has had associations with many famous men, but with no more notable inventor than Thomas Newcomen (1663–1729), to whom a memorial was erected in the Dartmouth gardens in 1921. In the previous year his name had been given to the Newcomen Society for furthering the Study of the History of Engineering, which to-day counts its members in Great Britain by the hundred but in North America by the thousand. Newcomen's contemporary engineer, Thomas Savery (? 1650–1715), was another Devonshire man, and both must have known Plymouth with its great Citadel. Among the towns of England, few suffered more from air raids, for its Guildhall and Church were laid in ruins, and of the Athenæum, long the home of the Plymouth Institution, little was left. Here for nearly a century and a half had been Plymouth's cultural centre, and among its most famous and active members was Sir William Snow Harris (1791–1867), the electrician whose lightning conductor for ships saved many vessels from disaster. An earlier scientific worthy of Plymouth was the preacher, chemist and porcelain maker, William Cookworthy (1705–80), at whose house Smeaton was always welcome when building the tower now on the Hoe and near which is the internationally known Laboratory of the Marine Biological Association, fascinating even to those with little knowledge of biology or the sea.

Plymouth is 226 miles from Paddington, Falmouth 291, and it is to Falmouth the student must go to learn what science and engineering has meant to Cornwall. In the quadrilateral formed by Falmouth, Truro, Hayle and Penzance, there are five important scientific institutions, the Camborne School of Mining, and memorials to a dynasty of engineers and inventors and discoverers. One of the societies is the Royal Cornwall Polytechnic Society, founded at Falmouth in 1833 mainly through the activities of the daughters of the Quaker physicist Robert Were Fox (1789–1877), Anna Maria and Caroline Fox (1819–71), the latter of whom left a journal full of delightful notes on the men of science she met. In 1933 the Society commemorated its centenary, and there were then twelve Foxes in the list of members and five on the Council. For more than a hundred years the Society has stimulated native talent in a score of ways and recorded the history of the county. Since 1868 it has also maintained a meteorological observatory.

From Falmouth a motorist can set out on a semi-circular tour which will take him to Penryn, where is the tomb of Jonathan Hornblower (1753–1815), a rival of James Watt; to Gwennap, where lies Michael

Loam (1797–1871), inventor of the 'man' engine for raising and lowering men in mines; and so to Truro, where can be seen the column to the explorers John and Richard Lander, and in the Cathedral the memorial to John Couch Adams (1819–92), whose birthplace was a farm not far from Launceston in the east of the county, but who is buried at Cambridge. North of Truro lies Chacewater, known for the great pumping engines of Newcomen, Smeaton and Watt, and at Redruth is the cottage in which Watt's assistant, William Murdoch (1754–1839), lived and which he lighted by gas. Not far away is the village of Illogan, the home of the engineering family of Tangye, and at Camborne the fine statue of Cornwall's greatest engineer, Richard Trevithick (1771–1833), unveiled on May 17, 1932, by the late Duke of Kent. For fifty years after his death, Trevithick had no memorial; now he has nearly a score. One of his homes was at Penponds, not far from Camborne, and nearby is Tuckingmill, where William Bickford in 1831 brought out his valuable invention of the safety fuse for mining, and at Hayle is the foundry from which many great pumping engines have come. Just south of Hayle is the village of St. Erth, the birthplace of a curate's son, Davies Giddy, later known as Davies Gilbert (1767–1839), sometimes referred to as the 'discoverer' of Davy. Educated at Oxford, he sat in ten parliaments, became a spokesman for science and was president of the Royal Society. He died at Eastbourne and his memorial is in the parish church there. Davy's birthplace was Penzance, where he was born in 1778. To-day his statue faces down one of the principal streets, reminding the passer-by of a great genius whose destiny took him to Dr. Beddoes's Institution at Bristol, to the Royal Institution and to the presidency of the Royal Society, and then by devious ways to a lonely grave in the old cemetery of Plainpalais at Geneva. He died at Geneva on May 29, 1829.

THE EASTERN COUNTIES

If instead of journeying from London through the south of England a traveller chooses to go east, he may be assured that his explorations will not go unrewarded. Essex in particular is rich in scientific shrines. At Upton House, Upton Park, near West Ham, on the borders of the ever-spreading London, the great surgeon, Joseph, Lord Lister (1827–1912), a second Jenner, was born, and the house, now the vicarage of St. Peter's Church, bears a commemorative tablet. His father was the Quaker microscopist, Joseph Jackson Lister (1786–1869). A little to the north of West Ham is Wanstead, where the astronomer, the Rev. James Pound (1669–1724), ministered and died. His early years saw some adventurous days in the Far East, but after being appointed to the living at Wanstead he turned his attention to the heavens, making observations which were of use to Newton, Halley and Laplace; but perhaps his most valuable work was the training in astronomy of his nephew Bradley. Farther north still, to the east of the town of Saffron Walden, lies the parish of Hempstead, in the church of which are the chapel and vault of the Harvey family, to which belonged William Harvey (1578–1657), the discoverer of the circulation of the blood. His brother Eliab built the chapel, and more than forty of the family have been buried in the great vault. In the middle of last century, inquirers found that Harvey's leaden coffin was deteriorating, and in 1883 the Royal College of Physicians, mindful of one of its benefactors, provided a marble sarcophagus for its reception. The sarcophagus was placed in the chapel, and on St. Luke's Day, 1883, in the presence of a congregation of physicians and surgeons, the coffin was transferred from the vault to the chapel and placed in the sarcophagus, and with it a copy of Harvey's works sealed in a leaden case. In 1883 the tower of the church was a ruin, but it has since been restored. Harvey's famous contemporaries, William Gilbert (1540–1603) and John Ray (1627–1705), were both Essex men, and both are buried and commemorated in their birthplaces, the former at Colchester and the latter at Black Notley, near Braintree. Both went to Cambridge, but whereas Gilbert became a physician and a great natural philosopher, Ray entered the Church but spent the greater part of his life travelling and botanizing; Gilbert has been called 'the father of electric and magnetic science', Ray 'the father of systematic botany and zoology'. Braintree is in the centre of Essex, and not far south of it is Witham, near which is Terling Place, the home of the Strutt family, from which descended John William Strutt, third Baron Rayleigh (1842–1919), the successor of Maxwell at the Cavendish Laboratory, Cambridge, of Tyndall at the Royal Institution and a president of the Royal Society. His tomb in a quiet corner of the churchyard has the words: "For now we see in a glass darkly, but then face to face. . . ."

Great men of science are not so numerous that every county can claim a Gilbert, a Ray and a Harvey; but neither Suffolk nor Norfolk is without its notable figures, especially in the realm of natural history. One of the keenest of students was the entomologist, the Rev. William Kirby (1759–1850), who first as curate and then as rector lived at Barham, Suffolk, for sixty-eight years, and there wrote, among other works, his well-known "Introduction to Entomology" in collaboration with William Spence (1783–1860). His botanical contemporary, Sir James Edward Smith (1759–1828), the founder of the Linnean Society of London, was born and died at Norwich, but is buried in the parish church of St. Margaret, Lowestoft. He had married Pleasance Reeve, and at his death was buried in the Reeve family tomb, where forty-nine years later his widow was interred, having attained the age of a hundred and three. Next among the botanical worthies came Sir William Jackson Hooker (1785–1865), director of the Royal Botanic Gardens, Kew, and John Lindley (1799–1865), professor of botany in University College, London, and Sir Joseph Dalton Hooker (1817–1911), the successor to his father at Kew and from 1873 until 1878 president of the Royal Society. The elder Hooker and Lindley were born at Norwich, the younger Hooker at Halesworth, in the church of which are memorials to him and his father. Still another botanist of note associated with Suffolk was Prof. John Stevens Henslow (1796–1861), Darwin's friend, who from 1839 was vicar of Hitcham, Suffolk, where he is buried. From one or other of the counties also came the mathematician and schoolmaster, John Mole (1743–1827), a farm labourer's son, who was born at Old Newton, Suffolk; Samuel Vince (1749–1821), the son of a bricklayer of Fressingfield, Suffolk, who became Plumian professor at Cambridge; and Robert Woodhouse (1773–1827), a Norwich man who succeeded Vince and did much to stimulate mathematical studies in the University of Cambridge.

To these names may be added that of Sir Robert Seppings (1767–1840), who was born at Fakenham,

Norfolk. Trained in the Royal Dockyards as a shipwright, he became surveyor of the Navy and designed many fine ships. He is the only naval architect to whom the Royal Society has given its highest award, the Copley Medal. After retirement, he lived at Taunton, where there is a memorial to him in St. Mary's Church, a part of the inscription being an extract from a report by a House of Commons committee.

Though the great county of Lincolnshire, second only in size to Yorkshire, has endless attractions, and though it contains the birthplaces of John Wesley, Tennyson, Sir John Franklin, George Bass, Franklin's cousin Matthew Flinders, and also of Dr. Robert Smith (1689–1768), the Plumian professor who founded the Smith Prizes at Cambridge and gave to Trinity College Roubillac's statue of Newton, for the lover of science no buildings can rival in interest the small manor house at Woolsthorpe, seven miles south of Grantham, in which Newton was born; Colsterworth Church, in the baptismal register of which is the entry: "Isaac son of Isaac and Hanna Newton, Jany. 1, 1643"; and Bishop Fox's Free Grammar School at Grantham, where Newton was taught by Henry Stokes. In 1858 Lord Brougham unveiled Grantham's fine bronze statue of Newton, and in 1927 the town was the scene of meetings commemorating the bicentenary of Newton's death, at which Sir J. J. Thomson, Sir Frank Dyson, Sir James Jeans and Sir Horace Lamb paid tribute to Newton's genius. Later on, in 1942, on a limited scale, and in 1946, on an international scale, the Royal Society commemorated in a worthy manner the tercentenary of Newton's birth, one outcome of which was that the Woolsthorpe manor house passed into the keeping of the National Trust and is thus preserved to the nation. The house is still inhabited, but the principal rooms are open to the public at certain times. Newton was not only born there, but it was to Woolsthorpe he returned in 1665 when the University of Cambridge was closed on account of the plague, and he remained there until 1667. "By the time of his return to Cambridge," said Prof. E. N. da C. Andrade in 1946, "it is tolerably certain that he had already firmly laid the foundations of his work in the three great fields with which his name is for ever associated—the calculus, the nature of white light and universal gravitation and its consequences. . . ."

With Cambridge and Cambridgeshire it is not proposed to deal, for excellent guide-books and histories are easily obtainable, giving particulars of the colleges and institutions and the many men of science who have added lustre to the University, and whom the University has honoured.

EVOLUTIONARY TRENDS AND CLASSIFICATION

A SYMPOSIUM with the general title of "Evolutionary Trends and Classification" was held by the Systematics Association in the Leeds City Museum on April 28. This meeting was of particular significance in that it represented the first implementation of a decision made by the Council of the Association to extend the activities of the Association to provincial centres. The organization was in the hands of a 'Northern Committee', but the meeting was in no sense a local one, for among the eighty zoologists, botanists and palæontologists attending were representatives of various institutions and societies from London to Edinburgh. The two sessions were under the chairmanship of, respectively, Captain C. Diver, director-general of the Nature Conservancy, and Prof. Irene Manton, professor of botany in the University of Leeds.

The first paper was given by Dr. O. W. Richards (Imperial College of Science and Technology, London), who posed the question "Is Phylogenetic Speculation Necessary to the Practising Taxonomist?" He pointed out that the work of the taxonomist is fourfold: the determination of specimens for other workers, the description of new species, the improvement of the arrangement of species and, lastly, the attempt to fit the facts into a phylogenetic scheme. The first three can be carried out without relation to the fourth, but the best classification (permitting successful predictions) will necessarily illuminate phylogeny, and, at the same time, some phylogenetic theory is always valuable as a working tool. For example, even convergence, if not too strictly conditioned by very specialized adaptation, may be an indication of a remote relationship in that the forms belong to one stock which still retains certain potentialities. 'Outside' evidence, such as data from geographical distribution, etc., is usually admitted in classification, and this automatically introduces the idea of phylogeny. Were this not the case, there is no reason why a genus should not consist of odd species dotted over the continents of the world, or why most wingless Diptera should not be considered to be allied. Nevertheless, it needs to be emphasized that many more facts are necessary to establish a probable phylogeny than may be necessary for mere identifications. For judging the correctness of phylogenies based on recent material, insects are very suitable. Five sources of 'outside' evidence which may be tapped are the rather scanty fossil record, the geographical picture, the cytological evidence (chiefly concerned with sex-chromosome mechanisms) and the foods of phytophagous species. The close correlation between this evidence and the morphological classification could only represent an incredible series of coincidences were this classification not a good index to phylogeny.

A strikingly different aspect of biology was dealt with by Prof. J. Small (Queen's University, Belfast), who dealt with "Trends in the Degree of Diversification in Diatoms". The Tertiary fossil history of this group of plants is known in considerable detail and shows great regularity. Drawing a sharp distinction between short-lived species ('Evanescent' or 'E') and long-lived ('Permanent' or 'P'), he showed that the latter appear to become unstable in their reproductive mechanisms at more or less regular intervals (of the order of seven million years), undergoing specific mutation to give rise to new species. Similarly, the oldest species will have produced the greatest number of varieties, etc. Generic origins and extinctions have maintained a balance with specific origins and extinctions so that the proportions of generic sizes have remained more or less constant. Merely recent or merely fossil genera rarely contain more than eight species. These findings are held to support the abrupt methods of speciation claimed by Willis and by Goldschmidt. It was suggested in discussion that there is much in this topic which might be discussed at a separate meeting.

Dr. A. J. Cain (University of Oxford) closed the morning session with a paper on "Local Evolution and Taxonomy in very Polymorphic Species", in which he showed, from his examples, that such polymorphy is highly dependent upon natural selection. His general conclusion was that 'micro-evolution' differs in no essential respect from the 'macro-evolution' illustrated by the large-scale trends seen by palæontologists. This was demonstrated, first, by reference to gastropods (particularly the genus *Cepæa*). Here, the variation of colour and banding patterns appears to be closely related to the background pattern, and this has been confirmed by marking experiments. The polymorphism of some birds, particularly the lorikeets, was also used to demonstrate that present-day geographic variation reveals evolution in progress. The taxonomist, faced with the necessity for describing such variation adequately, may be forced to abandon the typological method and adopt a notation expressing trends and not demonstrating conformity to a static description.

Mr. E. Milne-Redhead emphasized that such a notation is sometimes needed in botany too. Captain Diver and Dr. J. Crosby took part in the discussion, which was chiefly concerned with the significance of the variation between snail populations, and Dr. Cain replied.

In the afternoon, Dr. R. M. C. Eagar (University of Manchester) dealt with "Some Problems of Invertebrate Palæontology". In addition to difficulties provided by the nature and supply of fossil material, where the picture is clear enough, variation and change may be followed both vertically and horizontally. Thus, species in palæontology are, theoretically, arbitrary units. Where species are very variable and can be traced upwards through strata as a succession of apparently interbreeding communities, cross-sections of which have stratigraphical utility, classical taxonomy needs modification or replacement by a special utilitarian system. In the Anthracosiidæ, a binomial system of morphological species within natural groups has worked well for the stratigrapher and has been successfully applied to the description of small continuous changes. The establishment of the 'natural groups' is of great importance, and ultimately it may be possible to institute a trinomial nomenclature satisfying both stratigrapher and systematist. Nevertheless, there will long remain groups needing individual systems of terminology.

In the second afternoon paper, Dr. G. Heslop Harrison (King's College, Newcastle) spoke on "The Probable Origin, Phylogeny and Evolution of the Class Insecta, with Special Reference to the Classification of the Hemiptera–Homoptera". A new interpretation was given of the subjects indicated in the title. Examination of the evidence purporting to indicate 'explosive evolution' in the origin of the Insecta shows it to be unreliable, it being likely that much fossil evidence which might have stretched back to the Silurian has been removed by the very extensive Permo-Carboniferous glaciations. The probable times of origin and courses of events in the histories of various orders were reviewed, with particular attention paid to the Hemiptera. The shortcomings of the existing systems of classification in the Hemiptera–Homoptera were pointed out, and new alternatives based on phylogeny and evolutionary concepts were proposed. In the discussion which followed, P. C. Sylvester-Bradley claimed particularly that the evidence in favour of 'explosive evolution' is by no means refuted, particularly in the development of wings.

Prof. P. W. Richards (University College of North Wales, Bangor) then presented a paper entitled "Evolutionary Trends and Classification in the Bryophyta". He pointed out that the poor fossil record of the mosses and liverworts gives no solid basis for phylogenetic speculation. Various extensive morphological series established within the group (particularly by the work of Goebel) give strong evidence of evolutionary trends, usually from complex to relatively simple. Such a trend is well illustrated by the *Marchantia-Riccia* series in the Marchantiales. Here, the genus *Dumortiera* is generally similar in complexity to *Marchantia*, but the mature thallus lacks the system of air-chambers and pores. *D. nepalensis*, however, shows in the younger parts of the thallus partitions between air-chambers which break down without becoming functional. This trend of simplification has recently been confirmed by the genetic studies of Burgeff, who maintained cultures of *Marchantia* in which a remarkable range of morphological types arose as mutations, either spontaneously or following crossing. Many of the mutants and mutant-combinations resemble other, simpler, members of the Marchantiales.

Such a trend to simplification may depend upon the pressure of competition, which has restricted many species to temporary habitats with a consequent telescoping of the life-cycle. A classification which takes this into account will list complex species first; only Evan's classification of the liverworts has consistently followed this plan. In the subsequent discussion, Prof. A. R. Gemmell directed attention to the frequent association of bryophytes with fungi and inquired if this might be associated with the simplifying trend.

The last paper, given by Dr. J. M. Thoday (University of Sheffield), was a theoretical comparison of "The Units of Evolution and the Units of Classification". It was pointed out that systematists seeking explicitly for a natural unit of classification with a genetical basis attempt with some success to draw boundaries across which gene-exchange is so limited that the groups thus separated may be regarded as distinct units of evolution. However, the size and complexity of units of evolution vary according to the breeding system. Among vegetatively reproduced forms, obligate apomicts and obligatorily self-fertilized forms, the contemporary unit of evolution is the individual, while among out-breeders it is the population within which gene exchange occurs (and this may cover more than one species). Furthermore, breeding systems and structures may change and, with them, the size and complexity of the unit of evolution. Self-fertilized forms may become out-breeders or vice versa. Geographical or ecological barriers may break down so that two units may fuse, even if their species retain their essential identities. For these reasons, units of evolution cannot be, at the same time, satisfactory units of classification. If 'species' should become a word meaning 'unit of evolution', a new word will be required for the basic unit of systematics.

The longest discussion of the day followed this paper. Mr. P. C. Sylvester-Bradley directed attention to the usefulness of Gilmour and Gregor's 'deme' terminology. Dr. J. Crosby mentioned the greater ease with which out-breeding can give way to in-breeding rather than the reverse, and Dr. H. G.

Baker concurred. Prof. Manton pointed out that apomixis (loosely defined) is not an exclusively recent development, and pointed to those ferns which fall into neat species despite apogamy. Dr. Baker emphasized that the worst classificatory tangles involve facultative apomicts. Dr. Heslop Harrison pointed to similar occurrences in the insect world. Drs. Cain and Richards also spoke on the nature of classificatory units, and Dr. Thoday replied to all the points. Dr. Crosby suggested that the significance of the species should not be denied because there are groups in which other concepts are necessary. Thus, the meeting ended with a very hopeful augury of future discussion.

H. G. Baker

OBITUARIES

Prof. Aimé Auguste Cotton

Prof. Aimé Cotton, one of the most distinguished Frenchmen of his time and an experimenter of no mean order, died on April 16 at Sèvres. He was born on October 9, 1869, at Bourg-en-Bresse, where his father was a teacher of mathematics. He received his early education at the Lycée de Bourg, where he first became interested in experimental science, and at the Lycée de Clermont-Ferrand, where he received special training in mathematics. He entered the École Normale Supérieure in 1890, and hence came into contact with such men as Henri Poincaré, Emile Picard and Marcel Brillouin. In 1893 he became *agrégé des sciences*, and in 1896 obtained his doctorate.

Cotton's career as a scientific worker began at the University of Toulouse, where he was *maître de conférences* from 1895 until 1901. In 1900, he was given the title of professor in the University of Toulouse, and was also appointed *chargé de cours* in the École Normale Supérieure, where he was responsible for the training of students up to 1922; he was also on the staff of the corresponding girls' school, then at Sèvres, where he was assisted by his wife. While still on the staff of the latter institutions, he was appointed to the chair of theoretical and celestial physics at the Sorbonne in 1920, and to the chair of general physics in 1922. He was elected a member of the Paris Academy of Sciences in November 1923, and was president of the Academy in 1938.

At the outset of his career, Cotton made important discoveries concerning the absorption of circularly polarized light in coloured liquids. He found that when a beam of unpolarized white light, after traversing such a liquid, is submitted to examination by an analyser arranged for the detection of circularly polarized light, two differently coloured beams of different intensities were obtained. This was followed by the discovery of the phenomenon of anomalous rotatory dispersion—that in a coloured liquid which exhibits the property of optical rotation, the amount of rotation of the plane of polarization depends on the wave-length of the light in a manner quite different from that observed with uncoloured liquids. These two discoveries were of considerable importance in settling certain questions of molecular structure.

Following Zeeman's discovery of the effect of a magnetic field on emission spectra, Cotton carried out analogous experiments on absorption spectra, and showed that absorption lines were also changed by the application of a magnetic field to the absorbing medium; he discovered that the absorption spectrum of a coloured flame showed magnetic double-refraction effects in the neighbourhood of the absorption lines. In order to give greater precision to such measurements, Cotton devised a special form of electromagnetic balance for the measurement of magnetic fields, and he was able to prove that the Zeeman effect is independent of temperature. It is often forgotten that, in collaboration with Pierre Weiss, he determined the specific charge on the electron by measurements on the blue rays of zinc excited in an accurately known magnetic field.

Cotton was also associated with Henri Mouton in a series of important researches on ultramicroscopic particles, designing a special total-reflexion ultramicroscope for the purpose. Together, they examined the magneto-optical properties of colloids and found that these substances exhibited magneto-optical rotation and dispersion, in addition to the magnetic double refraction previously observed by Majorana. From these experiments they concluded that the colloid particles were anisotropic and so oriented themselves under the influence of a magnetic field. In England, the results of their great series of experiments on the magnetic double refraction of homogeneous organic liquids, analogous to the Kerr effect, are summarized as the Cotton–Mouton Law.

Because of these experiments, Cotton will always be remembered; but perhaps he will be even better remembered in Britain because he was the first to construct in 1928 a large electromagnet for experimental purposes. This magnet is lodged at Belle-Vue, Paris, and while bigger and possibly more efficient magnets have since been made, one must pay tribute to the great enterprise and vision which inspired its building. It continues to give good service, and during the War its work was supplemented by the building of a very large permanent magnet under the noses of the Germans.

Prof. Cotton was a very charming person, and will certainly be missed by a wide circle of friends. In his younger days he was associated with the defenders of Dreyfus. He was interested in Esperanto. In the First World War he took an active part in the development of sound-ranging devices. During the recent occupation of France he did not escape German attentions, and for some weeks was kept in Fresnes prison with some of his fellow academicians. He was three times honoured by the Academy of Sciences; he received the Pierson–Perrin Prize in 1907, the Caze Prize in 1918 and the Albert I of Monaco Prize in 1928.

We deeply sympathize with all his friends in their great loss, and in particular with Mme. Cotton, his wife, M. and Mme. Eugène Cotton (son and daughter-in-law) and M. and Mme. Manigault (son-in-law and daughter).

L. F. Bates

Mr. W. W. Davies, O.B.E.

William Whitridge Davies, head of the Administration Division of the Road Research Laboratory of the Department of Scientific and Industrial Research, died on May 19, aged fifty-one years, after a long and painful illness borne with great fortitude. He was a nephew of the late Sir Walford Davies, Master of the King's Musick.

Mr. Davies saw service at Gallipoli as a midshipman in the Navy in the First World War, and after qualifying and practising for some ten years as a civil engineer he joined the Building Research Station. There he took a leading part in the setting

up of the Fire Research Station at Elstree, and was then selected for one of the senior posts in the Road Research Laboratory.

Mr. Davies had great powers of industry and concentration: he was first and foremost a sound engineer, quickly able to seize upon the essentials of any technical problem. Not only had he a mind that was clear and precise, but he had also a profound feeling for the use of words and a deep appreciation of good literature. Everything that he wrote had a certain grace; it was accurate and yet readable.

The growth of the Laboratory, and his exceptional abilities in handling administrative problems, prevented him from taking an active part in the research projects, but this did not impair his vision of the directions in which progress could most fruitfully be made: thus he was a keen advocate of research in road safety, and took a large share in the formation and establishment in 1946 of the Traffic and Safety Division of the Road Research Laboratory. Men of his type work in the background of scientific endeavour, but they are essential to it. He combined an inner integrity of character with a charming courtesy and consideration for his friends and colleagues, for which they will long remember him.

T. Lonsdale

NEWS and VIEWS

Bacteriology at Glasgow: Prof. C. H. Browning, F.R.S.

At the end of this academic year, Prof. C. H. Browning retires from the chair of bacteriology in the University of Glasgow which he has held since its foundation in 1919. A distinguished graduate of Glasgow, Prof. Browning later worked in Frankfurt with Ehrlich, from whom he derived his life-long interest in chemotherapy. In 1914 he was appointed director of the Bland Sutton Institute at the Middlesex Hospital, where he successfully developed certain methods for the isolation of intestinal pathogens, for example, the brilliant-green enrichment technique, which had a valuable application during the First World War for the recovery of the causal organisms of enteric fever when present even in very small numbers. Further studies on antiseptics revealed the powerful antiseptic action of the amino-acridines which proved so useful clinically in the prevention of wound sepsis. Prof. Browning returned to the University of Glasgow as the first occupant of the Gardiner chair of bacteriology, and despite his many teaching duties, he has maintained a remarkable output of research both in the scientific journals and in books. In 1924 a second edition of the important work "Recent Methods in the Diagnosis and Treatment of Syphilis" was published (jointly), and, first with Sir Robert Muir and later with T. J. Mackie, Muir and Ritchie's "Manual of Bacteriology" was carried on from the eighth to eleventh editions. Further work on chemotherapy with Miss R. Gulbransen led to the discovery of the phenomenon of therapeutic interference, which has helped to advance knowledge of the underlying principles of specific therapeutic affinity. More recently, jointly with Morgan and Walls, certain phenanthridinium compounds were found to have a remarkable therapeutic effect on *Trypanosoma congolense*, which has proved extremely useful in field-trials on cattle in Africa. Prof. Browning was elected to the Royal Society in 1928 and received an honorary LL.D. from the University of St. Andrews in 1934. In university life Prof. Browning's greatest attribute has been his intense interest in fostering the spirit of inquiry among the younger men in both laboratory and clinical fields, and he has gone to endless trouble in discussing and planning researches and in helping the results to appear in print. For this he will also be gratefully remembered by many generations of Glasgow graduates.

Dr. J. W. Howie

Dr. J. W. Howie, head of the Pathology and Bacteriology Department and deputy director of the Rowett Research Institute, has been appointed to succeed Prof. Browning. After graduating in medicine at the University of Aberdeen in 1930, Dr. Howie worked for a year there in the Bacteriology Department and then transferred to the Departments of Bacteriology and Pathology at the University and Western Infirmary of Glasgow, where he began research on experimental streptococcal infection. During 1934–35 he was lecturer in morbid anatomy and histology at Aberdeen, and then during 1935–38 was assistant in bacteriology at Glasgow. In 1938 he returned once more to Aberdeen as lecturer in bacteriology. Dr. Howie volunteered for military service in 1940, and during 1941–43 served in West Africa, where, besides doing the laboratory work for the hospital at Ibadan, Nigeria, he was one of those responsible for advising on and carrying out the measures needed to prevent the spread of yellow fever by aircraft passing through Nigeria to Egypt and India. For the last two years of the War he was at the War Office and was editor of the *Army Medical Department Bulletin* and of *Current Notes for Army Pathologists*; he also edited and wrote substantial portions of the eighth (1946) edition of the War Office handbook, "Memoranda on Medical Diseases in Tropical and Sub-tropical Areas". In 1945 Dr. Howie returned to his teaching duties in the University of Aberdeen, and in the following year was appointed head of the Department of Pathology and Bacteriology at the Rowett Institute, Aberdeen, later becoming deputy-director of the Institute. Under his guidance the research programme of the reconstituted Department of Pathology and Bacteriology has been organized into three main parts: the influence of nutrition of the host on the course of bacterial infection; the role of the intestinal microflora in nutrition of the host; and the morbid anatomy and histology of the nutritional diseases of animals. Dr. Howie's own particular field is centred on the first of these, but since going to the Rowett Institute he has also become greatly interested in the second field.

Physics at Bristol: Dr. S. H. Piper

The valuable services of Dr. Stephen Harvey Piper to the University of Bristol have been recognized by the creation of a special chair in physics, to be held by him from August 1 next. Dr. Piper graduated from King's College, London, and obtained the degree of D.Sc. of London. After holding a research appointment at University College, Nottingham, he joined the Department of Physics at Bristol in 1921, and was elected reader in 1933. He has been assistant director of the Wills Laboratory since 1948. In 1923

Dr. Piper broke new ground by measuring the length of long-chain molecules and observing the linear relation between the crystal spacing and the chain-length of aliphatic compounds. Later, first with Francis and Malkin and then with Chibnall, he developed a method of applying such crystal measurements to the quantitative analysis of naturally occurring mixtures of aliphatic compounds, and to the elucidation of the metabolism giving rise to the production of plant waxes. In the First World War, Dr. Piper had a distinguished record with the Sherwood Foresters, with three mentions in dispatches and the award of the Distinguished Service Order.

William Bowie Medal of the American Geophysical Union: Dr. H. U. Sverdrup

THE thirteenth award of the William Bowie Medal of the American Geophysical Union (the executive committee of which is the Committee of Geophysics of the National Research Council) has been made to Dr. H. U. Sverdrup, director of the Norwegian Polar Institute, Oslo. Dr. Sverdrup is noted for a wide range of scientific interests which in the field of oceanography and meteorology are concerned principally with the physical aspects of oceans and the interaction of the sea and the atmosphere. As an explorer he has taken part in two north polar expeditions, namely, in Amundsen's ship *Maud* (1918–25) and in the Wilkins–Ellsworth submarine *Nautilus* (1931); at the moment he is directing the Swedish–Norwegian–British expedition in the Antarctic. While on the *Maud* expedition he did research work on terrestrial magnetism and electricity. One of the conditions of the award of the Bowie Medal is that the recipient must have made outstanding contributions in the advancement of co-operative research in geophysics, and this condition has been amply fulfilled, for Dr. Sverdrup is well known for promoting co-operation between scientific workers and institutions and among nations. During 1936–48 he was director of the Scripps Institution of Oceanography, University of California. The William Bowie Medal was first awarded in 1939 to the late William Bowie, the renowned geodesist and geophysicist, in whose honour it was established.

Ibadan University College, Nigeria

SIR SYDNEY PHILLIPSON has been appointed chairman of the Provisional Council of Ibadan University College, Nigeria; Sir Sydney was Financial Secretary in Nigeria during 1945–48, and was a member of the Provisional Council of the College until 1949. He takes over the chairmanship of the College Council from the principal, Dr. Kenneth Mellanby, who has temporarily served in this office since the establishment of the College in 1948. The rapid development of the College during the past three years has imposed increasingly heavy responsibilities on Dr. Mellanby in his dual capacity as chairman and principal, and the new appointment will enable Dr. Mellanby to devote himself entirely to the duties of the principalship. Ibadan University College has now more than 300 degree students and the number will rise to 600 in a few years. It has established faculties of arts, science, medicine and agriculture. The permanent buildings of the College are now under construction, and it is hoped that the work will be completed before 1954. Provision of £1½ millions for capital expenditure on the College has been made by H.M. Government under the Colonial Development and Welfare Acts.

Sickle-Cell Anæmia

IN this issue of *Nature*, two long communications (pp. 929 and 931) and two shorter ones (p. 950) refer to aspects of this active field of inquiry. Other recently published work on the subject can also be mentioned. Itano and Wells have determined the relative concentrations of sickle-cell and normal hæmoglobin among a considerable number of individuals showing sickle-cell trait and anæmia (*J. Biol. Chem.*, **188**, 65; 1951). Among 24 individuals showing the trait, the percentage of sickle-cell hæmoglobin varied continuously from about 24 to 45 per cent. Three mild cases of sickle-cell anæmia contained between 5 and 20 per cent of normal hæmoglobin. These results seem to indicate that all shades of variation may exist between the trait and severe anæmia, and suggest that the genetics of the disease may be more complex than has hitherto been supposed. Statistical surveys of the ratios of sickle-cell trait to anæmia may thus have little meaning, since it is impossible to guess the percentage of normal hæmoglobin present in any one individual on the basis of purely qualitative blood tests. An electrophoretic survey of the relative concentrations of normal and sickle-cell hæmoglobin, carried out among the members of large African families, may help to clear up some of the contradictions reported by Lehmann. The rarity of sickle-cell anæmia in East Africa was recently questioned by Foy, Brass and Kondi (*East African Med. J.*, **28**, 1; 1951), who report that out of thirteen mothers and infants of the Jaluo tribe whose cells showed sickling, four actually had the symptoms of sickle-cell anæmia. The discovery of foci of sickle-cell anæmia in villages around Lake Copais, a recently drained swamp in Greece, is recorded by Choremis, Zervos, Constantinides and Zannos in *The Lancet* of May 26, p. 1147.

Overseas Work of the British Council

IN connexion with the recent cuts in the Exchequer grants to the British Council, the overseas work of the Council requires consideration in relation to the work of other bodies. The B.B.C. foreign services contribute much to the friendly understanding of Britain by other countries, and the protests against the proposal to curtail that work have been as strong and widespread as those at the restriction of the overseas activities of the British Council. Assurance was, indeed, given in the House of Commons on April 9 that, in spite of the economies in the British Council and the B.B.C. foreign services, adequate sums will be available; and on April 11 the Foreign Secretary, Mr. Herbert Morrison, stated that increased provision is now being made for the B.B.C. overseas services. A Supplementary Estimate for £100,000 is to be presented to prevent the loss to the Corporation of the 'channel-hours' now in use for broadcasting to Europe.

This response to opposition in Parliament and in the Press to the reductions earlier announced in Treasury grants for overseas broadcasting ignores, however, the fundamental issue as to how broadcasting of this character should be administered, and its relation to other activities designed to promote the understanding of the British point of view. Furthermore, there is the technical point, which Mr. John Coatman has raised in correspondence in the *Manchester Guardian* of April 18, as to how far the objectives of overseas broadcasting are achieved by the present practice, on which at present some £11,000,000 is expended. He himself is convinced that British

counter-propaganda to Soviet propaganda should be a purely governmental activity directed and administered by a government agency, and it is easy to see reasons why it would be detrimental to the influence of either the B.B.C. or the British Council if either were used for propaganda purposes. This is, however, only one of the questions which Mr. Coatman suggests might form the subject at the present time of expert inquiry. He advocates that a small expert committee should consider first whether the political warfare kind of broadcasting should be carried out by a government department or agency, and the B.B.C. relieved of all such responsibility; next, the committee should consider the technical point whether exchange of transcription services is a more effective method than direct transmission; and finally, whether greater economy and efficiency could be achieved in this field by co-ordinating the work of the B.B.C., the British Council and the Central Office of Information. An inquiry of this type would, indeed, be worth considering, and it would also be of value in that it would satisfy the many who have testified recently to the value of the overseas work both of the B.B.C. and of the British Council, and are alarmed at the prospect of that work being diminished in present circumstances.

National Research Council of Canada: Review for 1949–50

The National Research Council of Canada has published "Review 1950" (N.R.C. No. 2254; pp. 278+11 plates. Ottawa: National Research Council, 1951. 75 cents), which describes in greater detail than does its annual report the work of the Council during the year ended December 31, 1949. It includes also some notes on early work in 1950 and is intended chiefly for scientific workers, research institutions and other persons or organizations requiring specialized information on the investigations in progress. There is also included a list of scientific staff arranged by Divisions and Sections. Lists of publications during the year are appended to the divisional reports and to those of the committees, and, besides a list of the outside committees on which the Council is represented, the report also includes an analysis of the distribution of scholarships, research fellowships and research grants made by the Council during 1949–50.

Features of the year which are emphasized in the report are the studies in applied biology which have led to modified designs of railway refrigerator vans and the adoption of new cooling mixtures, using ice, which lower the air temperatures by 3–6° C. Spray drying has been applied in the preparation of pure undenatured wheat gluten, and fermentation studies on wheat starch are yielding good results. New species of bacteria have been discovered which give a glycerol fermentation without producing 2 : 3-butyleneglycol. Solvent separation of rapeseed oil using furfuraldehyde as selective solvent continued, and work on the conditions of pressure, temperature, moisture content and straw size in making fuel briquettes was completed. Valuable contributions have been made to aerial photography through the development of special emulsions, and to surveying by means of 'Shoran' equipment. Work on turbine icing is being expedited, and research is proceeding on artificial precipitation or rain-making, by seeding clouds with dry ice, as well as on the development of apparatus for the generation, radiation and reception of microwaves. Cobalt-60 has been produced for use in medical and industrial radiology in place of radium, and more than twenty different radioisotopes have been supplied to universities, and research and other institutions.

Textile Institute: Annual Report for 1950

At the annual general meeting of the Textile Institute, held at the Town Hall, Manchester, on April 18, it was announced that new headquarters premises have been acquired at 10 Blackfriars Street, Manchester; these premises are much more spacious than those at present occupied at 16 St. Mary's Parsonage, Manchester 3, and it is hoped that the new premises will be ready for occupation by September. Wider recognition of the importance of the application of science and technology to the textile industry has led to a big influx of new members of the Institute in the past five years, membership having increased from 2,369 at the end of 1945 to 5,235 in 1950. An increase in the applications for fellowship and associateship of the Institute has also been recorded. Similarly, in the field of education, there has been a greater number of entries for the Institute's examinations in general textile technology, but concern is felt at the apparent lack on the part of candidates of that broad scientific foundation which is so essential to an appreciation of textile technology. This trend is shown by the total number of examinees and corresponding percentages of successes for the following years: 1948—114, 50·9 per cent; 1949—150, 45·3 per cent; 1950—192, 38·5 per cent. During the past year the circulation of the Institute's *Journal* increased to six thousand copies a month; also published during the year were the "Review of Textile Progress", edited jointly by the Institute and the Society of Dyers and Colourists, and the third issue of the Institute's "Year Book". A new Publication Fund, to be used for the expansion of the *Journal* and the publication of new text-books and other textile literature, was opened by a gift of £5,000 from the Rayon and Synthetic Fibres Producers' Committee. From the general financial point of view the year was very successful, 105 firms and associations being elected as patrons of the Institute, and for the first time for many years there was a surplus of income over expenditure.

Fifteenth Anniversary of the Theory of Mesons

In 1935, in the *Proceedings of the Physico-Mathematical Society of Japan* (**17**, 48), Prof. H. Yukawa published his now famous paper on the interaction of elementary particles, in which he suggested, *inter alia*, the existence of new particles, charged or uncharged, with mass about 200 times that of the electron. It is now generally believed that the π-mesons, the existence of which has since 1937 been firmly established experimentally, are to be identified with the particles suggested by Prof. Yukawa. To commemorate the fifteenth anniversary of the discovery of meson theory, the July/August 1950 number of *Progress in Theoretical Physics* consists, in addition to a special preface by M. Kobayasi and a bibliography of the more important papers relating to mesons published up to 1949, of a group of specially contributed articles. From outside Japan there are contributions by L. Rosenfeld, W. Heisenberg, W. Pauli, E. Fermi, G. Wentzel, W. Heitler, C. Bloch and R. E. Marshak. It is interesting to note that Prof. Fermi states that "the meson theory has been the dominant factor in the development of physics since it was announced 15 years ago by

Yukawa", and Prof. Wentzel confirms that "since the discovery of the π-meson it has become increasingly clear that this particle has basically the properties of a Yukawa particle". The periodical *Progress of Theoretical Physics* was founded by Prof. Yukawa in 1946, and he is a member of the editorial board.

Proceedings of the Rajasthan Academy of Sciences

THE first number of the *Proceedings of the Rajasthan Academy of Sciences*, which Academy was inaugurated at Pilani, India, in November 1949, to promote the progress of pure and applied science and to investigate the resources of Rajasthan (see *Nature*, **165**, 20; 1950), includes the scientific papers read at discussion meetings held during the first four months of the establishment of the Academy. In the second part of the *Proceedings* it is proposed to include lectures delivered on scientific subjects for general audiences. The present part, dated July 1950, includes papers on magnetic studies on potassium chromate (A. Mookherji), diamagnetic susceptibilities of paramagnetic ions (A. J. Jagannadham), the isomerization of aniline thiocyanate (R. D. and N. P. Gupta), the preparation of *d*-xylose from agricultural wastes to serve as starting material in the synthesis of *d*-ascorbic acid (K. Ramamurti) and a note, by B. V. Ratnam, on the occurrence of a polydelphous androecium in *Althæa rosea* and its morphological significance.

Scientific and Technical Journals published in South-East Asia

A LIST containing the titles of 125 scientific and technical journals published in South-East Asia has been compiled by the Unesco East-Asia Science Co-operation Office, Manila (pp. 28; 1950). The titles are arranged by countries under the Philippines, Indonesia, Malaya, Thailand and Indochina, and besides details of subscription and the source from which each journal can be obtained, particulars are included of the commencement of publication and of the series issued to date. The co-operation of users of the list in keeping it up to date by reporting errors or omissions or the publication of new periodicals, etc., is invited.

Histamine Antagonists

THE Chemical–Biological Coordination Center of the United States National Research Council has published Review No. 3, "Histamine Antagonists", by F. Leonard and C. P. Huttrer (pp. 122; Washington, D.C.: National Research Council, 1950; 1.50 dollars). This work gives a tabular survey of compounds having the specific property of counteracting the physiological effects of histamine. The release of free histamine in the blood is, as is known, responsible for pathological conditions, and histamine antagonists have a great interest in medicine.

M.K.S. System of Electrical and Magnetic Units

THE question of the M.K.S. system of units was considered by the Technical Committee on Electrical and Magnetic Units of the International Electrotechnical Commission at its meeting in Paris in July last year, and three points, among others, were recorded as follows. (1) In the light of the replies from the national committees to the inquiry made by the Central Office of the International Electrotechnical Commission, the 'newton' was finally adopted as the name of the unit of force in the M.K.S. system. (2) It is considered convenient to base the M.K.S. system on four principal units, and it is recommended that, for the purpose of developing the definitions of the units, the fourth principal unit should preferably be the ampere. (3) Rationalization is adopted for the M.K.S. system, which results in the following formulæ: $\mu_0 = 4\pi\ 10^{-7}$ for the permeability of free space (henry/metre); and $\varepsilon_0 = 1/\mu_0 c^2$ for the permittivity of free space (farad/metre); c being the velocity of light in free space, and ε the Commission's symbol for permittivity.

Lundy Field Society

APART from a list of birds recorded during 1950, which included the Balearic shearwater and the American pectoral sandpiper, the annual report of the Lundy Field Society for 1950 contains some notes on the birds of Lundy extracted from diaries kept between 1870 and 1905. While 1950 contains no record of the quail, an entry in the diaries for 1870 states that "men at mowing have destroyed five quail nests"; corn-crakes, too, were common in the last century but only one is recorded for 1950. The report also contains accounts of the distribution on Lundy of the water-snail, *Limnæa truncatula*, the longhorn grasshopper, *Leptophyes punctatissima*, certain small mammals including the pygmy shrew, *Sorex minutus*, and the black and brown rats, *Rattus norvegicus* and *R. rattus*, mosses, two-winged flies and butterflies and moths. Among other articles in the report is one by L. A. Harvey on the granite shores of Lundy, this being supplemented by lists of marine algæ and shore fauna; the latter includes nine species of tunicates. The report may be obtained from Mr. L. A. Harvey, University College, Exeter, price 2*s*. 6*d*.

Entomological Society of India: Officers

THE thirteenth annual general meeting of the Entomological Society of India was held on January 2, with Dr. H. S. Pruthi, plant protection adviser to the Government of India and retiring president of the Society, in the chair. During 1950 the Society was able to publish five numbers of the *Indian Journal of Entomology* at a total cost of more than Rs. 10,000 instead of the usual two issues. In view of the increased cost of printing, it was decided to raise the subscription rates of the *Journal* by about 25 per cent. Other prominent activities during the year were: a census of entomological workers in India; the dissemination of scientific information; efforts to establish a National Entomological Laboratory in India; and assistance in promoting international contacts between entomologists. The following have been elected officers for 1951–52: *President*, Dr. E. S. Narayanan (New Delhi); *Vice-Presidents* (from ex-presidents), Dr. H. S. Pruthi (New Delhi) and Dr. K. B. Lal (Kanpur); *Vice-Presidents* (new), Dr. I. M. Puri (Delhi) and Dr. K. N. Trehan (Ludhiana); *Councillors*, Shri S. Ramchandran (Coimbatore) and Dr. V. P. Rao (New Delhi); *Chief Editor*, Shri Y. Ramchandra Rao (Bangalore); *General Secretary*, Dr. S. Pradhan (Indian Agricultural Research Institute, New Delhi); *Joint Secretary and Treasurer*, Shri S. N. Chatterjee (New Delhi).

Histochemical Society: Officers

THE following have been elected officers of the Histochemical Society: *President*, Dr. David Glick (University of Minnesota); *Vice-President*, Prof.

Stuart Mudd (University of Pennsylvania); *Secretary*, Dr. R. D. Lillie (Pathology Laboratory, National Institute of Health, Bethesda 14, Maryland); *Treasurer*, Dr. E. W. Dempsey (Washington University, St. Louis).

Royal Aeronautical Society : Officers

THE following have been appointed officers for 1951–52 of the Royal Aeronautical Society: *President*, Major F. B. Halford; *Past Presidents*, Major G. P. Bulman, Sir John S. Buchanan, Dr. H. Roxbee Cox; *Vice-Presidents*, S. Camm, G. R. Edwards; *Honorary Treasurer*, C. F. Uwins; *Honorary Librarian*, J. E. Hodgson; *Secretary*, Captain J. Laurence Pritchard.

Congress on Building Science

A CONGRESS on building science will be held in London, for the most part at the Institution of Civil Engineers, during September 11–20, with Viscount Samuel as president. The purpose of the congress is to review the progress made in research in relation to architecture, building and the associated branches of civil engineering, and to consider developments in building and possible future trends. It is expected that the congress will attract a large number of architects, engineers, builders and contractors, in addition to men of science, from overseas. The programme is grouped into three main divisions. In the first, the congress will deal with the influence of mechanization and prefabrication on techniques and cost of building, of modern research on structural design, and of modern soil studies on the design and construction of foundations. Building materials will be considered in the second division; and in the third, the acoustics of auditoria and studios, the heating and ventilating of buildings in relation to summer and winter conditions, the lighting of buildings, and specific types of buildings (hospitals, factories and schools), will be the subjects of discussion. The papers will be printed and circulated beforehand. It is intended eventually to publish the proceedings of each of the three divisions in separate volumes. The congress is sponsored by the Royal Institute of British Architects, various engineering institutions, the Physical Society, the Society of Chemical Industry, the Department of Scientific and Industrial Research, the Ministry of Works, and the London County Council. The chairman of the organizing committee is A. G. MacDonald; and the organizing secretary, to whom applications for membership should be made, is K. Alsop, of the Building Research Station, Bucknalls Lane, Garston, Watford, Herts.

International Congress of Clinical Pathology

THE International Society of Clinical Pathology, which was founded in November 1947, will be holding its first international congress in London during July 16–20. The Congress is open to all interested persons. Sir Lionel Whitby will preside, and at the opening ceremony, to be held at 3 p.m. in Friends House, Euston Road, London, N.W.1, he will give an address on "The Science and Art of Medicine". The presentation of papers will be divided into four sections, dealing with microbiology, morbid anatomy, chemical pathology and hæmatology. Papers may still be accepted and should be sent, with a précis of not more than five hundred words, to the secretary-treasurer of the Congress. Demonstrations will be given in the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, where also will be held an exhibition of scientific instruments. The whole programme of the Congress, including abstracts of papers, will be reprinted during the late summer in a special supplement of the *Journal of Clinical Pathology*, obtainable from the British Medical Association, Tavistock Square, London, W.C.1; papers may be submitted in full to the editor, Dr. A. Gordon Signy, St. Mary Abbots Hospital, London, W.8, and if accepted will appear in subsequent issues of the *Journal*. Prior to the Congress the summer meeting of the Pathological Society of Great Britain and Ireland will be held in the Department of Pathology, University of Liverpool, during July 13–14, and will be open to pathologists visiting Great Britain for the Congress. All communications regarding the Congress should be addressed to the secretary-treasurer, Dr. W. H. McMenemey, Maida Vale Hospital for Nervous Diseases, London, W.9.

Conference on Auroral Physics

A CONFERENCE on auroral physics, jointly sponsored by the Department of Physics, University of Western Ontario, and the Geophysics Research Directorate, Air Force Cambridge Research Laboratories, will be held during July 23–26 at the University of Western Ontario, London, Canada. The general topics to be discussed will deal with the formation of auroras, the mechanics of solar corpuscles and the excitation mechanisms in the ionosphere (80–400 km.) and the mesosphere (400–1,000 km.). Particulars can be obtained from Prof. A. D. Misener, Department of Physics, University of Western Ontario, London, Canada.

Announcements

PROF. W. R. HAWTHORNE, George Westinghouse professor of mechanical engineering in the Massachusetts Institute of Technology, has been elected to the Hopkinson and Imperial Chemical Industries professorship of applied thermodynamics in the University of Cambridge (see also *Nature*, **163**, 355; 1949).

THE following have been appointed lecturers in the University of Leeds: Dr. T. H. Flewett (bacteriology) and E. Lightfoot (civil engineering).

PROF. L. HUNTER, professor of chemistry at University College, Leicester, has been appointed acting principal of the College pending the appointment of a successor to Mr. F. L. Attenborough, who is retiring.

MR. A. S. QUARTERMAINE, chief engineer, Western Region, British Railways, has been elected president for 1951–52 of the Institution of Civil Engineers.

A ONE-DAY conference will be held by the Northern Branch of Aslib on June 14 in the Council Chamber of the City of Birmingham. Two papers will be read, dealing respectively with some classification and indexing problems in an industrial information bureau, and the library of a daily newspaper, and there will be a discussion on the formation of a Midlands Branch of Aslib. The conference fee will be 3*s.* 6*d.* All communications should be sent to Miss E. Boddy, The Retreat, Tideswell Lane, Eyam, Sheffield.

ERRATUM. The new director of research of the British Food Manufacturing Industries Research Association is Dr. F. H. Banfield (*Nature*, June 2, p. 885).

X-RAY AND SOLUBILITY STUDIES OF THE HÆMOGLOBIN OF SICKLE-CELL ANÆMIA PATIENTS

By Dr. M. F. PERUTZ and Dr. A. M. LIQUORI
Cavendish Laboratory and Molteno Institute, Cambridge
AND
Dr. F. EIRICH
Polymer Institute, Polytechnic Institute of Brooklyn, N.Y.

IN a previous communication, Perutz and Mitchison[1] showed that the de-oxygenated red cells of sickle-cell anæmia patients contained reduced hæmoglobin in the crystalline state. In concentrated buffer solutions, the solubility of reduced hæmoglobin from such patients was found to be abnormally low. It was suggested that this low solubility, provided it persisted under physiological conditions, might be the cause of the crystallization of the reduced hæmoglobin inside the cell, and that this in turn might cause the 'sickling' phenomenon. We have now made a comparison of the solubilities of sickle-cell anæmia and normal hæmoglobin under physiological conditions, and have also repeated our earlier solubility studies in concentrated phosphate buffer, this time using the purified crystalline hæmoglobins instead of the hæmolysed material of the earlier tests. In addition, we have made a comparative X-ray study of sickle-cell anæmia and normal oxyhæmoglobin in order to see whether there are any obvious structural differences between the two molecules.

Crystallization and X-Ray Studies

Both normal and sickle-cell anæmia oxyhæmoglobin crystals, prepared by the method of Drabkin[2,3], consisted of tetragonal bipyramids of the type he described. Their birefringence and dichroism were weakly negative. X-ray analysis showed the two types of crystals to be isomorphous and to give X-ray diagrams identical in every detail, both as regards the dimensions of the unit cell (see Table, form 1) and the relative intensities of the X-ray reflexions. This was a most surprising result, considering that normally two related but slightly different proteins—for example, the hæmoglobins of closely related animal species—have totally different crystal structures. In this case, two hæmoglobins with different isoelectric points and different solubilities in the reduced state gave indistinguishable X-ray diffraction patterns and, on the X-ray evidence alone, might have been regarded as structurally identical.

A few drops of hæmoglobin solution, obtained by dissolving the tetragonal crystals in water, were added to 5 ml. phosphate buffer of *p*H 6·7, varying in concentration between 2·5 and 2·9 *M*. New crops of crystal grew in the buffer solutions, and this time normal and sickle-cell anæmia hæmoglobin crystallized in two structurally different forms, the sickle-cell anæmia form being one not previously observed. The crystals of normal oxyhæmoglobin were the orthorhombic bipyramidal prisms observed by Jope and O'Brien[4] and studied by Perutz and Weisz[5], whereas those of sickle-cell anæmia oxyhæmoglobin were orthorhombic needles or prisms terminated by domatic or pinacoid faces (Fig. 1). The two forms were readily distinguishable by their optics, the normal crystals being almost isotropic, while the sickle-cell anæmia crystals were strongly birefringent and pleochroic, with the direction of strong absorption and high refractive index parallel to the needle axis. The unit-cell dimensions and space groups are listed in the accompanying table, where form 2 refers to the normal and form 3 to the sickle-cell anæmia crystals. For the sake of completeness, the table also includes a fourth form which Jope and O'Brien obtained from normal carboxyhæmoglobin by precipitation with alcohol, but which was not encountered in the present study.

A series of cross-seeding experiments was now devised in order to see whether forms 2 and 3 really were characteristic of the two different proteins, or whether they were just polymorphous modifications common to both. The experiments showed form 2 to be the most stable one for normal oxyhæmoglobin, no matter which of the three crystal forms the solutions were seeded with. Solutions of sickle-cell anæmia oxyhæmoglobin seeded with form 2 also crystallized in this form. On the other hand, pure sickle-cell anæmia oxyhæmoglobin, in the absence of seeds, grew in form 3, whereas normal oxyhæmoglobin could never be grown in this form, even if large quantities of seeds were added. Form 3 was also obtained by adding to phosphate buffer a few drops

Occurrence	Form No.	Symmetry	Space group	Unit-cell dimensions (A.) *a*	*b*	*c*	$V \times 10^{-6}$ (A.^{3})	Molecules per cell	Molecular weight of asymmetric unit	Precipitation method
Normal and sickle-cell anæmia	1	Tetragonal	$P4_12_1$	wet 53·7		193·5	559	4	34,000	Dialysis of concent. HbO_2 solutions against 2·8 *M* phosphate buffer
				dry 47·4		174	392			
Normal; sickle-cell anæmia only when seeded	2	Orthorhombic	$P2_12_12_1$	wet 85·2	77·0	86·0	564	4	68,000	Addition of dilute HbO_2 to 3·2 *M* phosphate buffer
				dry 70·4	73·3	77·0	393			
Sickle-cell anæmia	3	Orthorhombic	$P2_12_12$	wet 202	107	53·2	1150	8	136,000	Addition of dilute HbO_2 to 3·2 *M* phosphate buffer
				dry 181	91·5	44·0	729			
Normal	4	Orthorhombic	$P2_12_12_1$	dry 50·0	55·0	123	338	4	68,000	Precipitation by alcohol

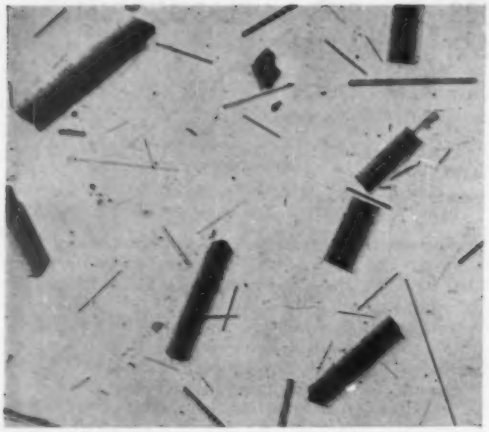


Fig. 1. Crystals of sickle-cell anæmia oxyhæmoglobin (× 50)

of oxyhæmoglobin solution obtained directly from the hæmolysis of sickle cells, without the intervening crystallization of the tetragonal form. Mixtures of the two proteins crystallized in form 2, probably forming mixed crystals. Thus forms 1 and 2 seem to be common to both proteins, whereas form 3 may be characteristic of sickle-cell anæmia oxyhæmoglobin alone.

Solubility

The solubility tests of Perutz and Mitchison[1] were carried out in concentrated phosphate buffer, using uncrystallized hæmoglobin obtained directly from the hæmolysis of red cells. These tests were now repeated, using the tetragonal oxyhæmoglobin crystals as starting materials and equilibrating the solutions at 0° C., instead of 20° C. as in the earlier tests (Fig. 2). The solubilities of the reduced hæmoglobins differed by a factor of ten, even though the two oxyhæmoglobins from which they were prepared had identical crystal structures. The solubilities of two samples of sickle-cell anæmia reduced hæmoglobin, one prepared from the crystalline oxyhæmoglobin and the other directly from a hæmolysate which had not been crystallized, were found to be identical.

We now tried to see whether the solubility of the sickle-cell anæmia reduced hæmoglobin was abnormally low also under conditions of salt concentration, *p*H and temperature approximating to those in the red cell. A suspension of sickle-cell anæmia red cells in Ringer phosphate was spun in an angle centrifuge until the cells formed a compact mass with very little liquid left between them. The hæmoglobin in one half of the cells was reduced by passing nitrogen over them for several hours, and that in the other half was converted into carboxyhæmoglobin. The cells were now hæmolysed by freezing and thawing them three times in succession. The two samples of hæmolysed material were equilibrated at 37° C. for several hours. They now differed strikingly in appearance. The carboxyhæmoglobin was completely dissolved and yielded no sediment on spinning; the hæmoglobin concentration of this solution was 29 per cent. The reduced sample was a solid mass from which no liquid could be removed by spinning; to measure the solubility of this hæmoglobin an equal volume of oxygen-free Ringer solution was added and equilibrated with the solid at 37° C. The final concentration of reduced hæmoglobin in the Ringer solution was only 4·6 per cent. This meant that the solubility of sickle-cell anæmia reduced hæmoglobin was no more than one-seventh of that required to keep it completely in solution inside the red cell. When the solid mass of reduced hæmoglobin was exposed to air and allowed to become oxygenated, it liquefied and became a hæmoglobin solution. The whole experiment was repeated with normal red cells, but no precipitate could be obtained either in the carboxylated or in the reduced sample; in both samples the hæmoglobin remained completely in solution.

Optical Studies

When examined under the polarizing microscope, the hæmolysed reduced mass mentioned in the previous paragraph was seen to be strongly birefringent, and gave the appearance of a liquid crystal (Fig. 3). When it was sheared between slide and coverslip, it became optically negative with respect to the direction of shear, which suggests that the hæm groups are normal to this direction. Since the hæm groups are invariably normal to the length of the needle-shaped sickle cells[1], it appears as though the birefringent mass is nothing but an assembly of needles of the type formed inside the cells, but of submicroscopic size. There is a close relation between this liquid crystalline material and the "tactoids" found in concentrated solutions of reduced sickle-cell hæmoglobin by Harris[7].

When a closely packed mass of reduced sickle cells is treated with saponin under nitrogen, it continues to look exactly like a mass of intact sickle cells. Evidently, the contents of the sickle cell, being solid and little soluble, are not dispersed on destruction of the membrane, but retain their shape unchanged. (This is in apparent contradiction to Ponder's observation[8] that sickled cells disperse on addition of lysin. Ponder's experiments, however, were done

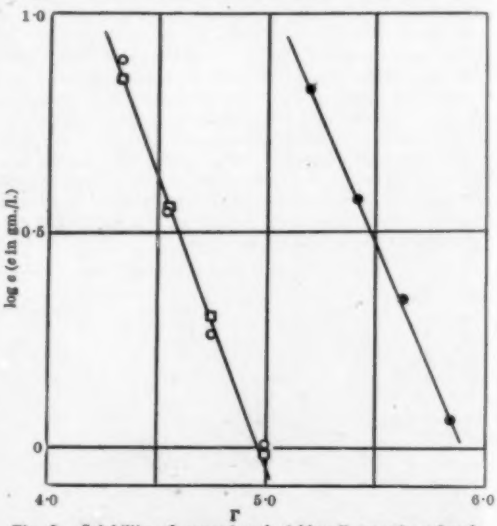


Fig. 2. Solubility of normal and sickle-cell anæmia reduced hæmoglobin in phosphate buffer at *p*H 6·7 and 0° C., as a function of ionic strength ($\Gamma = \frac{1}{2}\sum_i c_i z_i^2$)

●—●—, Normal hæmoglobin; □—□—, sickle-cell anæmia hæmoglobin, uncrystallized; ○—○—, sickle-cell anæmia hæmoglobin, crystallized

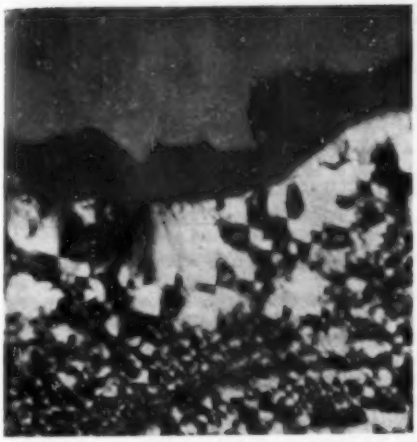


Fig. 3. Concentrate of sickle-cell anæmia hæmoglobin in Ringer solution between crossed nicols. The liquid crystalline reduced hæmoglobin forms a brightly lit pattern in the lower half of the picture. At the edge of the preparation, air penetrating under the coverslip has oxygenated the hæmoglobin and caused it to go into solution, forming an isotropic fringe

in a dilute suspension of cells containing enough liquid to dissolve all the reduced hæmoglobin, whereas we used a suspension consisting of about 80 volume per cent red cells, and therefore containing insufficient solvent for the reduced hæmoglobin inside them.) Normal red cells treated in the same way were found to be dispersed and turned into a clear hæmoglobin solution. Similarly, a clear solution was obtained on oxygenation of the saponin-treated sickle cells.

The optical studies of Perutz and Mitchison[1] were made with red cells reduced by hydrogen sulphide. It has been pointed out to us that this would have led to the formation of sulphhæmoglobin, which might have produced spurious results. However, a repetition of our experiments using red cells reduced under a stream of mixed nitrogen and carbon dioxide confirmed the previous findings.

Discussion

The concentration of hæmoglobin in the human red cell is about 34 per cent by weight. Our experiments show that the solubility of reduced sickle-cell anæmia hæmoglobin is too low for more than one-seventh of this concentration to be present in solution. Though a certain degree of supersaturation would have to be expected, it appears likely, from this figure, that the reduced hæmoglobin in the cell will begin to solidify long before the cell becomes completely deoxygenated, at least in patients containing no normal hæmoglobin. Thus sickling would not necessarily require complete de-oxygenation of the cell. On the other hand, the presence of even small quantities of normal hæmoglobin, such as found by Wells and Itano[9], would probably raise the solubility of the hæmoglobin in the red cell considerably, so that more extreme de-oxygenation would be required to bring on sickling. This may be the reason why in such cases the disease is less severe.

As to the structural differences between normal and sickle-cell anæmia hæmoglobin, our crystallographic results provide no clue, but merely serve to emphasize the close similarity between the two proteins. Complete identity of the X-ray diffraction pattern could never occur if any gross differences existed between the chemical structure of the polypeptide chains or their number or arrangement in the molecules. To give identical unit-cell dimensions, the dimensions of the molecules must be identical and the structural differences between them must be so located that they do not influence the intermolecular forces in the particular crystal lattice. To give the same relative X-ray intensities, the differences must be such that they do not alter the mass distribution in more than a small fraction of the molecule. This view is in general agreement with the close similarity in amino-acid composition found by Schroeder, Kay and Wells[6].

We are indebted to Dr. D. Drabkin for his advice and for a gift of large tetragonal hæmoglobin crystals. We wish to thank Dr. Janet Watson, Dr. C. A. Steson, Dr. A. D. Barlow and Dr. P. Pritchard for gifts of sickle-cell hæmoglobin, and the Medical Research Council for financing most of the work. One of us (A. M. L.) wishes to acknowledge the help of Dr. I. Fankuchen during the preliminary X-ray studies.

[1] Perutz, M. F., and Mitchison, J. M., *Nature*, **166**, 677 (1950).
[2] Drabkin, D. L., *J. Biol. Chem.*, **164**, 703 (1946).
[3] Drabkin, D. L., *Arch. Biochem.*, **21**, 224 (1949).
[4] Jope, H. M., and O'Brien, J. R. P., "Hæmoglobin", 269 (London, 1949).
[5] Perutz, M. F., and Weisz, O., *Nature*, **160**, 786 (1947).
[6] Schroeder, W. A., Kay, L. M., and Wells, I. C., *J. Biol. Chem.*, **187**, 221 (1950).
[7] Harris, J. W., private communication.
[8] Ponder, E., *Ann. N.Y. Acad. Sci.*, **48**, 557 (1947).
[9] Wells, I. B., and Itano, H. A., *J. Biol. Chem.*, **188**, 65 (1951).

SICKLE-CELL ANÆMIA AND SICKLE-CELL TRAIT AS HOMO- AND HETEROZYGOUS GENE-COMBINATIONS

By Dr. H. LEHMANN

St. Bartholomew's Hospital, London, E.C.1*

IT is now an accepted fact that the sickle-cell trait is two to three times more frequent among the Bantus and Nilotes of Africa than in American Negroes; nevertheless, sickle-cell anæmia is found often in America, and only rarely in Africa.

Beet[1], in a survey of some 2,000 North Rhodesians, found only one case of the specific anæmia, and later published another. Lehmann and Milne[2] and Lehmann[3] saw only two cases of sickle-cell anæmia during the investigation of several hundred East Africans, many of whom were anæmic, that is, of a population selected to show a weighting for the incidence of the disease. In similarly selected material (hospital post-mortem cases) Raper[4] found only two cases in Uganda. Trowell and Muwazi[5], also in Uganda, surveyed 126 children suffering from malnutrition; 25 were sicklæmic, but only few suffered from an anæmia which could be ascribed to sickle-cell hæmolysis. Mackey[6] in Dar-es-Salaam watched especially for patients suffering from sickle-cell anæmia, but in the course of two years found only one; yet he estimates that there must be some eight thousand sickle-cell trait carriers in that town. Similar results have been reported from Angola and West Africa[7–9].

* Formerly of Makerere College and Mulago Hospital, Kampala, Uganda.

The reports from America on the ratio of sickle-cell anæmia to trait vary. It is usually assessed at 1 : 9, but even the most conservative estimate[10] expects at least one case of specific anæmia for every fifty carriers of the trait. Raper[11], in a survey of the literature from Africa, suggests that there the ratio must be well below one in a thousand.

Beet[12] and Neel[13] have recently suggested that sickle-cell anæmia occurs when the dominant gene for the trait is homozygous, and that individuals in whom it is heterozygous remain carriers only. It is difficult to reconcile this theory with the facts as found in Africa. With an incidence of the trait of 20–30 per cent in many tribes there should be found among them many thousands of individuals with the double-dominant gene, and, if the 'sickle-cell anæmia in homozygotes' theory were correct, one would expect the disease to be at least as frequent in Africa as it is in America.

One possible explanation for this discrepancy could be that the gene is lethal, and that homozygotes die earlier than the rest of the population. For this reason an analysis was made of the age distribution of sickling in some Uganda tribes. The specification of tribes is necessary in such an investigation, as the incidence of sickling varies from tribe to tribe[14].

Sicklæmia was tested for by incubating drops of blood with a drop of an oxygen-consuming broth culture of *Bact. coli*[15], and the donors were subdivided according to their appearance into four groups: the very old, white-haired and toothless; fully-grown adults; children; and babes in arms. The sex ratio was noted, as it has been suggested that the sicklæmia is slightly more frequent in women.

Table 1. Age Distribution of Sicklæmia in Three Tribal Groups, One with Low and Two with High Incidence of the Trait

Tribe	Age group	Number examined (percentage of males shown in brackets)		Per cent sicklæmic
Sebei	Old	10	(100)	0
	Adults	88	(86)	1
	Children	21	(57)	0
	Infants	5	(40)	0
Bagishu	Old	23	(100)	26
	Adults	142	(77)	27
	Children	36	(58)	44
	Infants	6	(33)	17
Lango	Old	18	(100)	39
	Adults	82	(77)	34
	Children	57	(68)	30
	Infants	19	(100)	37

Table 1 shows that in the Sebei, a Hamitic tribe with a sickle-cell trait incidence of less than 1 per cent, there was the same absence of sickling among younger and older members of the tribe; and that there was no fall in incidence of sicklæmia with increasing age in groups of Bagishu and Lango, for example, of tribes with a high sickle-cell trait incidence.

The incidence of sicklæmia was also determined in mothers and their recently born babies. The infants were younger than three months and older than two weeks. This latter fact is noteworthy, because a previously reported incidence of sicklæmia in new-born infants[9] was criticized because, in testing, a chemical reducing agent was used which was also mildly hæmolytic. It was considered possible that, in view of the difficulty of reducing fœtal hæmoglobin, hæmolysis had set in in some cases before the reduction of the blood was sufficiently advanced to produce sickling.

Table 2. Incidence of Sicklæmia in Mothers and their Infants from Three Tribes with Low, Medium and High Incidence of the Trait, respectively

Tribe	Mothers		Infants		Number of sicklæmic mothers with sicklæmic infant
	No.	Sicklæmic	No.	Sicklæmic	
Suk	14	0	14	1	0
Teso	37	9	47	9	5
Lango	19	5	19	7	2
Total	80	14	80	17	7

Table 2 shows the sickling incidence in groups of mothers and their suckling babies from the Suk, Teso and Lango tribes. The first are Hamites with a low incidence of sicklæmia; the second a Hamitic tribe with much Bantu admixture and an incidence of sicklæmia of about 20 per cent; the last, the Lango, a Nilotic tribe, show a yet higher incidence of sicklæmia[14]. There is no striking difference between the sickle-cell trait incidences in mothers and their babies, such as one would expect if homozygotes died in early infancy.

The results shown in Tables 1 and 2 suggest that sickling can be found at similar frequency at all ages. Short of death *in utero* or very soon after birth—and both are events which could not have escaped the attention of medical officers in African maternity wards—the explanation for the rarity of sickle-cell anæmia in Africa cannot be accounted for by a 'lethal' double-dominant factor.

Another finding makes it unlikely that in Africa homozygotes suffer from sickle-cell anæmia, die early and thus escape observation. The incidence of sickling among the pygmoid Baamba is 45 per cent[14]; this percentage of sicklæmics must include homozygotes.

In this connexion one more observation may be recorded. Elsdon-Dew[16] rightly points out that Lehmann and Raper[14] in their survey of sicklæmia in African tribes have not recorded the precautions they took against sampling errors. In fact, care was taken to have a fair sample and to avoid so far as possible 'family clusters'. Thus, as in other tribes, the figures for sicklæmia in the Karamajong were obtained by testing school children, inmates of prisons, voluntary station labourers, hospital patients, people attending health inspections or church gatherings and so forth, that is, individuals coming from areas as diverse as possible. Among 156 individuals five cases of sicklæmia were thus found, and the percentage of sicklæmia for the Karamajong was reported as 3·2. Not included for the above reasons were findings in an isolated place near Lutomi, Karamojo, where, of 53 individuals (41 male), no less than 46 showed sickle cells. All these individuals derived from a single kraal in which there was close intermarriage. The finding was checked by repeating the tests on one day on 26 members of this 'isolate' and on 35 Karamajong children fifteen miles distant in a Government school in Moroto.

While the finding on the members of the Lutomi community had to be discarded from the sampling point of view, so far as the tribal survey was concerned, it is additional evidence for the claim that sickle-cell gene homozygotes must survive in Africa.

The two cases of sickle-cell anæmia seen by Lehmann and Milne[3] both had sickle-cell parents and siblings, and it may well be that the double-dominant

gene is necessary for the disease; but a simple theory suggesting sickle-cell anæmia as the expression of sickle-cell trait in homozygotes will not suffice.

A possible explanation for the difference seen between American Negroes and Africans has been advanced by Raper[11]. In the New World, 300 purely negroid Caribs from Honduras, "people who have preserved wholly their integrity as a coloured race", showed a trait incidence of 8 per cent, but no case of sickle-cell anæmia was seen among them over the past thirty years[17]; on the other hand, in Africa, where so few cases have been seen among the native population, three have been reported in Indians, one in an Arab and one in a White. Raper suggests that the appearance of sickle-cell anæmia may depend on some factor imported by marriage with persons other than Africans. This would explain why there is a high incidence of the disease among American Negroes, who have mixed considerably with other races, and why the condition is rare among the people from whom the trait originated.

[1] Beet, E. A., *E. Afric. Med. J.*, **23**, 75 (1946); *ibid.*, **24**, 242 (1947).
[2] Lehmann, H., and Milne, A. H., *E. Afric. Med. J.*, **26**, 247 (1949).
[3] Lehmann, H., *Lancet*, **i**, 90 (1949).
[4] Raper, A. B., *E. Afric. Med. J.*, **26**, 14 (1949).
[5] Trowell, H. C., and Muwazi, E. M. K., *Arch. Dis. Childhood*, **20**, 110 (1945).
[6] Mackey, J. P., *E. Afric. Med. J.*, **26**, 172 (1949).
[7] Teixeira, A. W. G., *An. Inst. Med. Trop.*, **1**, 356 (1944).
[8] Evans, R. W., *Trans. Roy. Soc. Trop. Med. Hyg.*, **39**, 207 (1945).
[9] Robertson, W. M., and Findlay, G. M., *Trans. Roy. Soc. Trop. Med. Hyg.*, **40**, 435 (1947).
[10] Neel, J. V., *Medicine*, **26**, 115 (1947).
[11] Raper, A. B., *Trop. Med. Hyg.*, **53**, 49 (1950).
[12] Beet, E. A., *An. Eug.*, **14**, 279 (1949).
[13] Neel, J. V., *Science*, **110**, 64 (1949).
[14] Lehmann, H., and Raper, A. B., *Nature*, **164**, 494 (1949).
[15] Singer, K., and Robin, S., *J. Amer. Med. Assoc.*, **136**, 1021 (1948).
[16] Eladon-Dew, R. E., *Nature*, **165**, 763 (1950).
[17] McGavack, T. H., and German, W. M., *Amer. J. Med. Sci.*, **208**, 350 (1944).

EFFECT OF THYROXINE ON CREATINEPHOSPHOKINASE ACTIVITY

By BRIGITTE A. ASKONAS

Biochemical Laboratory, Cambridge

HYPERTHYROIDISM or prolonged thyroid treatment affects the activities of various enzyme systems. Some enzymes show increased activities (such as muscle hexokinase[1], succinoxidase[1], D-amino-acid oxidase[2, 3] and cytochrome oxidase[4] of rat liver), whereas lactic dehydrogenase in liver[5] and rat serum pseudocholinesterase[6] appear to be less active than in control animals. Apart from a slight activation of some aged succinoxidase preparations[7], thyroxine, so far, has not been shown to exert any *in vitro* or short-term effects on isolated enzyme systems.

In the present study, it was found that DL- and L-thyroxine *in vitro* strongly inhibited the activity of purified creatinephosphokinase (see Fig. 1). This enzyme catalyses the reaction

$$\text{creatinephosphate} + \text{adenosinediphosphate} \rightleftharpoons \text{creatine} + \text{adenosinetriphosphate}.$$

L-Thyroxine produced an inhibition of about 20 per cent at a concentration of 10^{-5} *M* and 40–50 per cent at a molarity of $2{\cdot}5 \times 10^{-5}$. The inhibition appears to be non-competitive (Fig. 2). The enzyme, purified

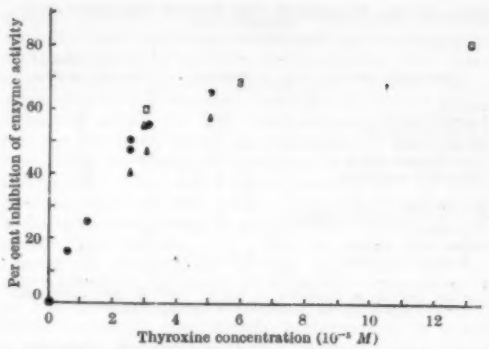


Fig. 1. *In vitro* inhibition of purified creatinephosphokinase by DL- and L-thyroxine

□, recrystallized DL-thyroxine (B.D.H.); ●, L-thyroxine ($a^{21°}_{D} = -5{\cdot}4$); ▲, L-thyroxine in the presence of 0·001 *M* glutathione

The reaction mixture contained 0·005 *M* Mg^{++}, 0·05 *M* glycylglycine buffer *p*H 7·3, 0·0026 *M* phosphocreatine, 5 γ of enzyme protein per ml. and 0·001 *M* glutathione where indicated. $t = 30°$. The enzyme was incubated in the reaction mixture + thyroxine for 15–20 min. before starting the reaction with 0·0026 *M* adenosinediphosphate

from rabbit muscle with *n*-propanol[8], was free from adenosinetriphosphatase and myokinase and did not liberate any inorganic phosphate from creatinephosphate or adenosinediphosphate. Hence the amount of phosphate transferred from creatinephosphate to adenosinediphosphate could be measured by determining the creatinephosphate content of the samples by the method of Fiske and SubbaRow[9]. With crude freeze-dried muscle extract, 10^{-4} *M* DL-thyroxine (B.D.H.) inhibited the enzyme activity by 60 per cent. On account of the low solubility of thyroxine and related compounds, it is difficult to study the *in vitro* effects of high concentrations of inhibitor accurately.

It appears unlikely that the inhibition is due to an oxidation of the —SH groups of the enzyme, since excess glutathione added before the enzyme protein does not alter the effect of thyroxine, and yet protects the enzyme against such oxidizing agents as free iodine and iodosobenzoate (Table 1).

To investigate the specificity of the reaction a number of substances were tested, compounds either related to thyroxine or with thyroxine-like or anti-thyroxine properties. Glutathione was added to avoid any possible effect of free iodine or metal impurities. Table 1 shows that thyronine and 3,5-diiodotyrosine, the physiologically inactive precursor of thyroxine, do not affect the activity of purified creatinephospho-

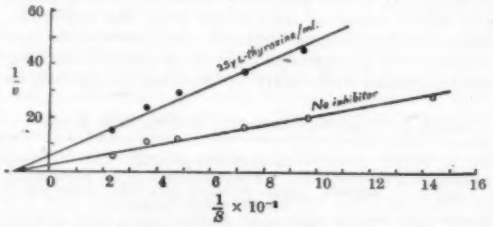


Fig. 2. Non-competitive inhibition of creatinephosphokinase activity by L-thyroxine *in vitro*

The reaction mixture was the same as described in Fig. 1. *v* represents the initial velocity expressed in terms of mgm. phosphate transferred/min./5 γ of enzyme protein. *S* represents the concentration of adenosinediphosphate and creatinephosphate

Table 1. *In vitro* Experiments with Purified Creatinephosphokinase*

Substance added	Molarity	% Inhibition of rate of reaction
Iodine	10^{-4}	10
Iodosobenzoate	10^{-4}	5
2,4-Dinitrophenol	10^{-3}	0
DL-Thyronine	4×10^{-4}	5
L-3,5-Diiodotyrosine	10^{-4}	0
Tetrachlorothyronine	$0{\cdot}7 \times 10^{-4}$	36
	$1{\cdot}4 \times 10^{-4}$	50
Tetrabromothyronine	$0{\cdot}5 \times 10^{-4}$	38
Hydroxy-3,5-diiodomethyl-benzoate	10^{-4}	0
	2×10^{-4}	33
O-benzyl-3,5-diiodo-N-acetyl-L-tyrosine	$1{\cdot}3 \times 10^{-4}$	40

* Reaction mixture as described in Fig. 1. 10^{-3} *M* glutathione was added except in the case of dinitrophenol.

kinase at concentrations of 10^{-4} *M*. In addition, 2,4-dinitrophenol, which has an enhancing effect on metabolism, does not change the enzyme activity. However, the chloro- and bromo-analogues of thyroxine inhibited the enzyme activity almost as much as thyroxine. These derivatives seem to have the same qualitative effects as thyroxine in myxœdematous patients but to a lower degree[10]. Similarly, the last two antithyroxine compounds in Table 1 inhibited creatinephosphokinase activity, although a considerably higher concentration was required than with L-thyroxine. Both compounds exert antithyroxine activity when administered to mice simultaneously with thyroxine[11]. The mechanism of their action is obscure.

It is not certain whether the *in vitro* reaction represents a specific inhibition of the enzyme or not. Because of the high activity of the enzyme, a very small amount only of protein can be used for velocity determinations (for example, 5 γ of protein per ml. of reaction mixture); thus the inhibition by thyroxine may be due to a blocking of the surface by adsorption of the large iodinated molecules on the protein, rather than to a specific inhibition of this particular enzyme.

Many difficulties are encountered in the assay of the enzyme in *in vivo* experiments. The enzymic determinations have to be carried out on crude muscle extract in the presence of various interfering enzyme systems. It is also difficult to extract the enzyme quantitatively by the usual methods of mincing and grinding. A few preliminary *in vivo* experiments were carried out in conjunction with Dr. R. H. Smith. The short-term effect of a single large dose of DL-thyroxine (B.D.H.) administered subcutaneously (8 mgm./kgm. body-weight) was investigated in male hooded rats, weighing 180–200 gm. The control animals received an injection of an equivalent volume of dilute alkali adjusted to the same *p*H as the thyroxine solution. The animals were killed seven to nine hours after the injection. Creatinephosphokinase activity was determined immediately on an aqueous extract of minced hind-leg muscle, diluted sufficiently for the rate of reaction to be proportional to the enzyme concentration. The protein concentration in the extracts of both groups of animals appeared equal as judged by the dry weight and the ultra-violet absorption of proteins at 278 mμ after dialysis. The results (Table 2) show a statistically significant decrease of 25 per cent in the creatinephosphokinase activity of muscle from thyroxine-treated rats compared with the control animals.

Table 2. Short-term Effect of DL-Thyroxine *in vivo*

Group of rats	Number of animals	Mean creatinephosphokinase activity (mgm. phosphate/min./ml. aqueous muscle extract 1 : 20)	Standard deviation
Control	6	0·423	±0·009
Thyroxine-treated	5	0·315	±0·027

Statistical analysis: $t = 8{\cdot}6$
$P < 0{\cdot}001$

The long-term effect of a total dose of 20 mgm. of DL-thyroxine/kgm. body-weight injected over a period of a week was studied in rats (260–300 gm.) pair-fed with a vitamin-supplemented diet[1]. The animals were killed twenty-four hours or longer after the last injection. Since the muscle extract of the hyperthyroid animals showed a mean increase in dry weight of 18 per cent over the control animals, the results were expressed per mgm. of dry weight. The results (Table 3) were not consistent and showed considerable individual variation. Only in seven out of eleven pairs of animals was the creatinephosphokinase activity decreased by 10 per cent or more in the thyroxine-treated animals as compared with the control animals.

Table 3. Long-term Effect of DL-Thyroxine *in vivo*

Group of rats	Mean creatinephosphokinase activity*	
	Experiment 1 (7 rats)	Experiment 2 (4 rats)
Control	0·265 (s.d. ±0·019)	0·45 (s.d. ±0·026)
Thyroxine-treated	0·235 (s.d. ±0·027)	0·439 (s.d. ±0·06)

* Activity is expressed as mgm. phosphate transferred/min./mgm. dry weight of muscle extract.

It must be pointed out that the dose of thyroxine in the short-term experiments was very large. On the other hand, rats are known to be relatively resistant to thyroxine treatment. It is evident that a more detailed study of the *in vivo* effect of thyroxine is needed to reach any definite conclusions. At present it is therefore difficult to evaluate the significance of the above findings and their possible relation to creatinuria in hyperthyroidism and the decreased amount of phosphocreatine in muscle of hyperthyroid rabbits[12], symptoms which would be expected if the enzyme were inhibited.

I am grateful to Dr. R. H. Smith for his invaluable assistance and for provision of muscle from thyroxine-treated rats. I should like to thank Dr. M. Dixon and Prof. F. G. Young for their interest and advice. My thanks are also due to Mrs. R. Pitt-Rivers for some pure L-thyroxine and its chloro- and bromo-analogue, Prof. N. F. Maclagan for antithyroxine compounds, Dr. B. A. Hems (Glaxo, Ltd.) for thyronine and L-thyroxine, and the Medical Research Council for a grant.

[Dec. 12.

[1] Smith, R. H., and Williams-Ashman, H. G., *Nature*, **164**, 457 (1949).
[2] Klein, J. R., *J. Biol. Chem.*, **128**, 659 (1939).
[3] Cagan, R. N., Gray, J. Z., and Jensen, H., *J. Biol. Chem.*, **183**, 11 (1950).
[4] Tipton, S. R., Leath, M. J., Tipton, I. H., and Nixon, W. L., *Amer. J. Physiol.*, **145**, 693 (1945).
[5] Vestling, C. S., and Knoepfelmacher, A. A., *J. Biol. Chem.*, **183**, 63 (1950).
[6] Hawkins, R. D., Nishikawara, M., and Mendel, B., *Endocrinol.*, **43**, 167 (1948).
[7] Aloisi, M., and Cavallini, D., *Arch. fisiol.*, **41**, 1 (1941).
[8] Askonas, B. A., *Biochem. J.*, **48**, 42 (1951).
[9] Fiske, C. M., and SubbaRow, Y., *J. Biol. Chem.*, **81**, 629 (1929).
[10] Lerman, J., and Harington, C. R., *J. Clin. Invest.*, **27**, 546 (1948).
[11] Wilkinson, J. H., Sheahan, M. M., and Maclagan, N. F., *Biochem. J.*, **46**, xxvii (1950).
[12] Wang, E., *Acta Med. Scand. Supp.*, **169**, 81 (1946).

BRITISH SCIENTIFIC INSTRUMENTS IN PARIS

EARLY last year an exhibition of French scientific instruments was held in the Science Museum, South Kensington. It aroused so much interest that M. René Varin, of the French Embassy, suggested to the British Council that a similar exhibition of British instruments in Paris would have a like success. Thanks to the co-operation of French scientific men and the willingness of British industry, universities and government research organizations to collaborate, the British Council was able to arrange an exhibition during May 11–17 at the Sorbonne. The rooms made available for this purpose adjoined those in which the French Physical Society was holding its annual exhibition of scientific instruments, and visitors could circulate freely from one exhibition to the other.

The new venture was an undoubted success. The exhibits, all selected for their excellence and topical interest, were 'live' in the sense that they showed the products of the instrument maker in use as research tools. In this way the French visitor not only saw up-to-date equipment both in the development and finished stages, but was also afforded a direct insight into the research work of some of the leading and most productive laboratories of Great Britain. The exhibits were explained by enthusiastic demonstrators familiar with their subjects, and whenever language difficulties arose bi-lingual representatives of the British Council and of French scientific research laboratories were ready to help. A descriptive catalogue in French gave details of the thirty-nine exhibits and of the nature of the work with which they were associated. Explanatory display cards were also provided.

A complete list of exhibits would be out of place here; but it would be true to say that all evoked much interest, while the almost permanent congestion about some marked them out as 'high-lights' from the French point of view. Among these were the micro-manipulators, the Geiger counters and cathode-ray tubes, and the electron diffraction and metal evaporating equipments. The cosmic-ray photographs shown by University of Bristol workers and those taken on the Pic du Midi by University of Manchester students and illustrating the disintegration of *V*-particles were outstanding attractions. The demonstration from King's College (London) of the application of the reflexion microscope in biology, the galvanometers used at University College (London) in physiological research, and the vacuum torsion balances of the British Electrical and Allied Industries Research Association all attracted much attention. Among exhibits from government laboratories, the electronic calculating machine from the National Physical Laboratory, the Radio Research Station's automatic ionosphere recorder (which functioned throughout the run of the exhibition without a hitch), the Atomic Energy Research Establishment's machine for producing quartz fibres, the Telecommunications Research Establishment's millimetric wave spectrometer and the 2,000-channel frequency-generator and automatically recording resistance extensometer of the Royal Aircraft Establishment aroused eager and continual interest and discussion.

There was a time when the man of science could keep abreast of the work of his colleagues by private correspondence and through publication. This is no longer possible. Enormously increased scientific activity and growing complexity of experimental methods have so swollen the literature that direct interchange of ideas and experiences is now vital to progress. This is made all the more necessary by the breaking down of the compartmentation within science owing to the rapid expansion of the borderline fields of research between two or even more disciplines. The need is only partially met by international conferences, which touch but lightly on techniques and methods, being more concerned with results and conclusions. But the ways by which results are obtained are no less important, and here the mutual interchange of visits to laboratories is of the greatest possible value. This exhibition of British scientific instruments and research is a step in the right direction in that, to some extent at least, it opened the laboratory of the British experimental scientific worker to inspection by his French colleagues, just as, during their week's stay, British visitors were given facilities to see the laboratories of the leading scientific organizations in France. It is to be hoped, therefore, that this kind of exhibition exchange between the two countries may become a regular event. There is no room for isolationist nationalism in the development of instruments and techniques for scientific research.

The exhibition was opened by Prof. E. N. da C. Andrade, and during the week lectures were given by him, Dr. V. E. Cosslett and Prof. G. I. Finch on recent work carried out in their laboratories. Yet another link between French and British science was forged by the award to Sir Thomas Merton on May 15 of this year's Holweck Prize given jointly by the Société Française de Physique and the Physical Society.

The following French scientific bodies gave valuable assistance in the organization of the exhibition: the Centre National de la Recherche Scientifique, Office National d'Études et de Recherches Aeronautiques, Commissariat à l'Énergie Atomique and the Société Française de Physique.

G. I. FINCH

TELEVISION STATION AT BIRMINGHAM

AT a meeting of the Radio Section of the Institution of Electrical Engineers on May 9, a symposium of three papers was presented on the technical features of the television broadcasting station at Sutton Coldfield, near Birmingham, which was opened for public service on December 17, 1949.

The first paper, presented by P. A. T. Bevan and H. Page, described the design, construction and service performance of the Sutton Coldfield station, which was built by the British Broadcasting Corporation as a first step in the extension of its television service to the provinces. By adopting vestigial sideband transmission for the vision programme, in place of the double sideband method installed at Alexandra Palace, London, before the Second World War and still in use there, it has been possible to provide five independent channels within the band 41–68 Mc./s. allocated to the television service in Great Britain. At Sutton Coldfield, there are two very-high-frequency transmitters—a 42-kW. vision transmitter and a 12-kW. sound transmitter, operating on carrier frequencies of 61·75 and 58·25 Mc./s.,

respectively. The station site is 550 ft. above sea-level, and both the sound and vision signals are radiated from the same aerial system, comprising two tiers of four vertical half-wave folded dipoles, erected at the top of a mast 750 ft. high. The design and method of feeding this aerial system from the transmitter are such as to give a horizontal radiation-pattern, which is substantially uniform in all directions and over the required band of frequencies. A field-strength survey from the new station has been carried out by the B.B.C., and this has shown that, up to a range of about fifty miles, the field strength is generally greater than 0·5 mV./m. Based on experience of viewing conditions, it is considered that reception within this area will be good, but may be subject to interference where local conditions are severe. A useful signal of 0·1 mV./m. or more can be received at distances up to sixty-five miles from the transmitting station, but this may be subject to severe interference and to some fading. Viewing conditions at greater distances, while still possible, will depend markedly on the terrain between transmitter and receiver and on the occurrence of favourable weather conditions.

The paper by Bevan and Page includes a description of the layout of the station and equipment at Sutton Coldfield, the power supplies and control mechanism, and the aerial and transmission-line system. The vision transmitter itself was described in more detail in the second paper, by E. A. Nind and E. McP. Leyton, in which it is pointed out that in some respects the new transmitter resembles that of the London station erected in 1936. In both cases high-level modulation is used; but in order to reduce liability to amplitude distortion, the output radio-frequency amplifier of the Sutton Coldfield transmitter is cathode-driven, whereas in the former case grid-drive was used. The description of the transmitter given in this paper is general where the technique is well established, but is more detailed where novel parts of the equipment are concerned.

The third paper presented at the meeting, that by E. C. Cork, describes the design, construction and performance of the vestigial sideband filter circuit installed at the Sutton Coldfield station. The basic design formulæ relevant to the filter network are given, together with a description of the practical circuit and construction adopted. The results of measurements of the attenuation characteristics of the filter show that there is good agreement between its performance and that of the idealized network.

These three papers form a very good and useful record of the design, construction and equipment of the first high-power television broadcasting station to be built in the world.

INSTABILITY OF SMALL PLANETARY CORES

TWO papers, by W. H. Ramsey and M. J. Lighthill, respectively, "On the Instability of Small Planetary Cores", have recently been published (*Mon. Not. Roy. Astro. Soc.*, **110**, 4; 1950). Previous papers by Ramsey on the subject, to which reference has been made in *Nature*[1], suggested that the large jump in density at the boundary of the earth's core is not due to the appearance of new material but to a phase transition under pressure. Variation of density within the earth is, then, primarily due to the influence of pressure, and seismology provides the pressure–density relationship for the material. On the assumption that the other terrestrial planets have the same chemical composition as the earth, their mean densities can be computed, and Ramsey's results have been published[2]. In the course of the calculations it was found that very small cores are unstable and for this reason would not occur in Nature—a direct consequence of the main assumption that the jump in density at the boundary of the core is controlled by pressure.

A more comprehensive treatment of the subject is given in the two latest papers; in the first one, by Ramsey, it is assumed that the planets are composed of a material which is incompressible, both above and below the critical pressure, and in the second paper, by Lighthill, it is shown that the main conclusions of Ramsey's paper are valid also in the case of a compressible material. The problem is beset with many difficulties and, as Ramsey admits, in its more general form is mathematically cumbersome, but the assumption of incompressibility adds considerably to a simplified treatment of the subject. It is impossible in this article to do more than merely indicate some of the conclusions attained.

It is shown that the mass M is normally an increasing function of the pressure P, that is, dM/dP is normally positive. If the mass be M_0 when the critical pressure p_c is attained for the phase transition at the boundary of the core, the derivative dM/dP is discontinuous, and Lighthill shows that the derivative alters by a factor $(2\lambda - 3)/\lambda^2$, if the density jumps from ρ_0 to $\lambda\rho_0$ at the critical pressure, so that the derivative becomes negative if λ exceeds 1·5. Hence the mass decreases below M_0, attains a maximum value M_1, and then increases again. As a consequence of this a planet can exist in three different equilibrium states if its mass lies between M_0 and M_1, which Ramsey denotes by A, B and C. State A has no core and states B and C have cores, that in state C being the larger. While states A and C are stable, state B is unstable, and a transition from A to C or from C to A is prevented by the energy barrier separating them. But if the mass is M_0 or M_1, a transition is possible; in the former case A and B coalesce, C being the only stable state; in the latter case B and C coalesce and A is the only stable state. As the masses M_0 and M_1 depend on the thermal condition of the planet, and as the mean internal temperature of a planet may have changed by 10,000° C. or more during its evolution, M_0 and M_1 could alter by about ten per cent. This possibility is important, because it is not essential that a planet should be in the critical mass range M_0–M_1 during its entire history. Moreover, this possible variation in temperature is not based on any theory of the origin of the solar system.

For the terrestrial planets M_0 is about 0·80 M_E, where M_E is the mass of the earth. While this is smaller than the mass of Venus by about 2 per cent, it is conceivable that M_0 could have changed by this amount during geological time, and hence Venus might have undergone a transition by this amount in this period; but Venus and the earth are the only planets to which this could have happened. A planet crossing the critical range, passing from one configuration to another, would release energy of the order 10^{37} ergs and could remove 0·1–1·0 per cent of the mass from the surface, and blast-waves and vibrations of the planet as a whole would shatter the material, fragments flying off into space. It is

tentatively suggested that this mechanism has been responsible for meteorites and possibly minor planets. It is admitted that the complexity of the problem prevents a complete quantitative treatment; and far from closing the question of the origin of these bodies, the present work should be regarded as re-opening this question.

[1] Ramsey, W. H., *Nature*, **163**, 814 (1949), and **165**, 217 (1950).
[2] Ramsey, W. H., *Mon. Not. Roy. Astro. Soc.*, **108**, 5 (1948).

1851 EXHIBITION SCHOLARS

CENTENARY DINNER

RECENTLY in this Festival year in Great Britain a very special celebration was held: on the evening of May 1, exactly one hundred years after the date of the opening of the Great Exhibition in Hyde Park, about 130 men of science gathered together to dine and to do homage to the Prince Consort and other founders of that great achievement. All this company had one common bond between them: each had at some time in the early part of his career been awarded an 1851 Exhibition Scholarship which enabled him to continue his postgraduate studies in scientific research.

As is well known, the 1851 Exhibition made a handsome profit, and this was first put to the purchase of a site in Kensington, which now houses the great museums of science and art, the Imperial College of Science and Technology and other educational institutions. Part of the site was developed and now brings in further substantial income. One of the projects which the Prince Consort had discussed was, however, not realized until thirty years after his death. In 1891 the Royal Commission for the Exhibition of 1851, under the inspiration of Lord Playfair, brought into being the first major scholarship scheme to aid young research students in Great Britain and in other parts of the Empire. Thus was started a fraternity of men of science, the total number of which now comes to nearly eight hundred, although unfortunately many of them are not now living. Out of these, more than three hundred went from the Dominions to Great Britain or other parts of Europe to complete their training. The members of the fraternity are now dispersed widely throughout the Commonwealth, the United States and other countries, where they play a leading part in academic and in applied science. Nearly eighty scholars have later in their career achieved the distinction of being elected to the Royal Society, and six have won Nobel Prizes.

The dinner on May 1 was held at University College, London, and the scholars had as their guests the members of the board of management of the Royal Commission and the members of the Science Scholarships Committee, together with a few others associated with the Exhibition trusteeship. The chair was taken by Lord Macmillan, who, after reading a message of goodwill from H.R.H. the Princess Royal, president of the Royal Commission, proposed a toast to the memory of the Prince Consort. In vivid style, Lord Macmillan described the difficulties that had to be overcome before the Great Exhibition could be started; he then recalled the words of Lord Playfair shortly after the Scholarship scheme was inaugurated, to the effect that if the scheme produced one Faraday a gift would have been presented to the country which would have been cheap at a million pounds. The career of Rutherford alone, a Scholar of 1895, could be considered to have fulfilled Lord Playfair's hopes, though there are a great many other 1851 Exhibition Scholars whose contributions to science are internationally recognized. A toast to the guests was proposed by Sir Irvine Masson (Scholar of 1910) and seconded by Dr. J. J. Sudborough (Scholar of 1891), one of the few survivors of the first group of appointments. These Scholars expressed the feelings of all those present in their appreciation of the valuable part 1851 Exhibition Scholarships had played in their own careers. The reply to their toast was made by Sir Henry Dale, and Sir Robert Robinson, who was present in the dual capacity of an 1851 Scholar and a member of the Science Scholarships Committee, expressed the company's thanks to the chairman.

The Scholars were particularly pleased to have with them that evening Sir Evelyn Shaw, who was secretary to the Commissioners during the period when most of the company had held their scholarships. He played a major part in the many happy reunions that went on that evening. Five hours later on the same day, a similar though smaller dinner was held in New York. Greetings were sent from the London dinner to Prof. H. S. Taylor for transmission to their New York colleagues. A further centenary dinner, for Canadian Scholars, was held in Montreal on June 2.

BREEDING HABITS OF THE SWIFT

DURING the years 1944–49, A. F. Cutcliffe and others made 250 visits to the tower of a church in Ilfracombe, Devon, to study the breeding habits of the swift (*Apus apus*); the visits were made at hours ranging from 6 a.m. to 12 midnight. An account of the observations appeared in a recent issue of *British Birds* (**44**, No. 2; February 1951).

The nests are situated above the bells at a height of 80 ft. from ground-level. Under the eaves of the tower on the east and west sides are a number of holes through the wall, some of which are occupied in early spring by nesting house-sparrows (*Passer domesticus*), which the swifts expel when they arrive, using these and any unoccupied apertures for breeding purposes. In this way the new arrivals find ready-made nests to which they add other materials. One such nest contained three eggs laid by the sparrow owner before being evicted. The nests on the north and south sides of the church tower are made entirely by the swifts. Fourteen nesting sites have been used by breeding swifts during the period of observation, though not all have been occupied in any one year.

The first observations revealed that the nesting area was littered with skeletons of swifts, the casualties of past years, no fewer than thirty-eight complete skeletons, mostly of young birds, being counted. The nests and the surroundings contained many dark brown egg-capsules which were later identified as those of the two-winged fly, *Crataerhina pallida*.

The bases of the nests are constructed of hay and straw, the shallow cups being formed chiefly of small white feathers, identified as coming from gulls which abound in the district. Pieces of red and blue string

and a fragment of red-coloured tinfoil were also found among the nesting materials.

On one occasion a swift was seen to steal nesting material from a sparrow's nest in a neighbouring building, despite the protesting occupant. Feathers from sparrows have been found mixed with the white lining of the nest cups.

During the period in which observations were made the earliest arrivals were noted on April 27; the latest on May 10.

During the ten or twelve days following the first arrivals some of the nests were usually occupied by one bird only—possibly males. On one occasion two swifts were found in a nest after arrival, both fast asleep.

On a few occasions coition was witnessed at the nesting site, the female clinging vertically to a beam; it is also believed to have occurred in the nest, but was not clearly seen. Simulated coition was observed many times while the birds were in flight in late July, by which time most nests contain young birds. Possibly non-breeding birds were involved; but this was not established.

Each year a number of non-breeding birds is present in the tower. In 1949 six non-breeders helped to make up the colony of twenty adult swifts. The non-breeders arrive in early May and nightly occupy a nest throughout the breeding-season, usually in pairs. One such couple, ringed in 1948, returned in 1949 and bred, using the nest in which they had been ringed.

Generally the first eggs are laid about the last week in May, but in 1949 an egg was laid on June 28, and it is known that in 1945 laying occurred on approximately July 6.

The nesting records vary considerably and, if a cold, rough or wet spell of weather be experienced, the eggs are sometimes thrown out of the nests or destroyed by the swifts. Eggs replaced by the observer are again ejected. Following this a second clutch is sometimes laid and young hatched out; but in several cases no second clutch was laid.

Inclement weather affected both adults and young, the former being confined to the nest for days at a time. Starvation and death often resulted, particularly to the nestlings. The presence of both adults in the nest over long periods resulted in the hatching of many of the parasitic dipterans, *Crataerhina pallida*. They caused much irritation to the birds, which were constantly scratching themselves to get rid of the insects. A number of small red mites was also present in the nests and upon the birds at this time. The combined effects of starvation, parasitic flies and mites on the recorded deaths cannot easily be assessed, but must have been considerable.

During the exceptionally fine summer of 1949, when adults spent the maximum time away from the nests, not a single casualty occurred; of parasites also there were exceptionally few. When parasites were present, DDT was applied to both nests and birds; all parasites were destroyed. In all cases newly arrived migrant swifts were free from parasites.

Incubation is chiefly carried out by the females, which remain with their young throughout the first fortnight after hatching. The males relieve their mates occasionally during the daytime, particularly in the early evening; but the females return to the nests about an hour before nightfall. For the first two or three weeks after hatching, especially if the weather were unsettled, the males would be found roosting in the nests with the females or near by. When the weather was very fine, one parent, probably the male, would often spend the night away from the nest and even from the tower. Where they pass the hours of darkness was not ascertained.

Towards the end of the fledgling period the young are often left alone in the nests at night.

The beginning of early return migration occurs towards the end of July and, according to Cutcliffe, the adults and young of early nests migrate first, followed by (presumed) males from nests that still contain young, and then by non-breeders.

The departure of the later-breeding adults and of the young generally takes place during the month of August. The latest to be recorded was in 1945 and took place on September 8.

PHYSICS OF LUBRICATION

THE Manchester and District Branch of the Institute of Physics and the British Rheologists Club (now the British Society of Rheology) held a symposium in the University of Manchester during June 29–July 1, 1950, on the subject of the physics of lubrication. An edited edition of the papers delivered at the symposium and of the discussion has recently been published as a supplement to the Institute's *British Journal of Applied Physics**.

The contents are divided into two parts: (1) hydrodynamic lubrication and the rheology of lubricants, and (2) boundary-layer and extreme-pressure lubrication. The first paper in Part 1 is by Prof. D. E. Christopherson, of the University of Leeds, who gives a general survey of hydrodynamic lubrication, referring in particular to the basic assumptions of lubrication theory, the effects of temperature and pressure on the behaviour of lubricants, the bearing metal surface, and to the question of the occurrence of negative pressures and cavitation. The three other papers in this section deal with the rheology of lubricant films, the viscosity of lubricating oils at high rates of shear, and the lubrication of cotton and other textiles. Part 2 opens with an introductory paper by Dr. D. Clayton, of Imperial Chemical Industries, Ltd., in which a comprehensive review is given of the general background of the subject and of the subject-matter discussed in the succeeding thirteen papers. The non-specialist will find this introductory paper of particular value.

The symposium was held in order to bring together those working on the subject of lubrication in industrial, government and university laboratories. The papers are reports of individual pieces of research, and readers of the Supplement, lacking the atmosphere of the symposium, will not be able to derive the best benefit from the articles, although Prof. Christopherson's and Dr. Clayton's surveys will be of considerable assistance. Nevertheless, the series of articles do form, as the editor hopes, a clear and concisely written progress report. The elegant presentation, with the most useful addition of detailed subject and name indexes, make the Supplement, even at the somewhat high price of 15*s*., well worth having on the library shelves of all institutions having members interested in problems of lubrication and its application.

* Physics of Lubrication. *Brit. J. App. Phys.*, Supp. 1. Pp. viii + 96. (Institute of Physics, 47 Belgrave Square, London, S.W.1, 1951.) 15*s*.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Spiral Growth on Carborundum Crystal Faces

In 1949 Frank[1,2] pointed out the possibility that growth of crystals at low supersaturations, essential for good crystals, could take place because of the formation of dislocations in the crystal so that any real crystal should have a number of dislocations with a screw component, terminating on the face. When growth takes place on these exposed molecular terraces, the edges of these layers develop into spirals centred on the dislocation.

Griffin[3] has observed these 'monomolecular' layers on the $(10\bar{1}0)$ face of a beryl crystal, and has shown by multiple-beam interferometry that the height of these steps is less than 34 A., that is, less than four unit cells of the crystal. It was inferred that these steps are only one unit cell high.

In the present investigation, numerous 'growth spirals' have been observed on the faces of carborundum and measured with the aid of phase-contrast microscopy and multiple-beam interferometry.

Carborundum[4] occurs in at least eight known types, one of which is cubic, whereas the rest are either hexagonal or rhombohedral and have identical layers but differ in their arrangement and are uniquely distinguished by the number of layers in the unit cell. The crystals studied here are of type I (rhombohedral, fifteen layers, with lattice parameter c = 37·7 A.), and type II (hexagonal, six layers, c = 15·1 A.).

These spirals were studied by coating the crystal faces with a thin film of silver of reflectivity nearly 90 per cent, deposited by thermal evaporation, and then examining these faces in reflexion.

Theory shows that for growth taking place from vapour, the ledge extending from the point of emergence of the dislocation to the crystal boundary has a rate of advance independent of the crystallographic orientation, thus forming a simple Archimedean spiral which can be calculated and from which the constant of spacing between turns can be predicted. These predictions have been completely confirmed numerically by the circular spirals shown in Fig. 1.

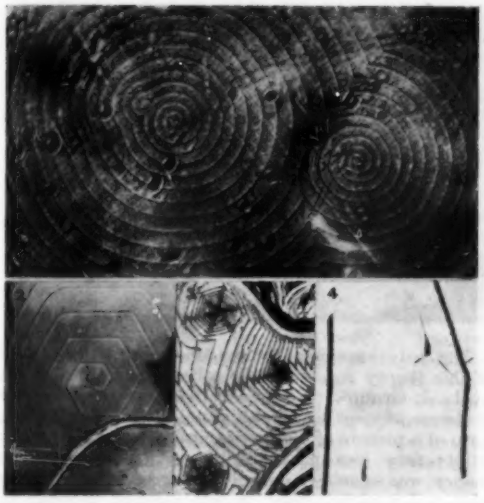
The dependence of the rate of advance of a growth front on the orientation of the step line should impose a characteristic distortion of the growth of spirals, exhibiting the crystal symmetry. In accordance with this, Fig. 2 shows a hexagonal spiral (crystal type II). The straight edges correspond to a sharp minimum in the growth-rate as a function of orientation.

The complex growth patterns predicted for two or more screw dislocations ending on a crystal face and depending on the property of growth fronts which annihilate each other where the two edges meet are illustrated in Fig. 1. Thus for two screw dislocations of opposite hand, with the unfolding of the two spirals the ledges starting from one terminate on the other, generating closed loops.

Various other growth patterns for two, three and larger numbers of dislocations ending on crystal faces of type I and type II have been photographed and explained.

Interlacing of hexagonal spirals observed on a crystal face of type II is illustrated in Fig. 3.

The observed density of dislocations varies widely on different specimens, ranging from a few to a maximum of $\sim 10^4$ per sq. cm. On any crystal they are predominantly of one hand.



The calculated radius of the critical nucleus is 2 μ and the supersaturation 0·2 per cent.

To measure the step height of these spirals, multiple-beam interference (Tolansky[5]) has been employed. Fig. 4 shows the Fizeau fringes for λ 5,461, passing over a circular spiral, in which the height can be accurately measured; and as the number of turns is readily visible, the height of each single step can be deduced with precision. Analogous measurements have been made also with fringes of equal chromatic order. The step heights on a type II crystal measured from two different spirals are respectively 15·2 A. and 15·1 A., with a maximum uncertainty of 2 A. It is already known from X-ray analysis that, for type II, c = 15·1 A. Thus it has been proved here that the step is a single unit-cell high.

The observation of spiral markings on carborundum has already been reported[6]. The observed shapes of these spirals are in accordance with the predictions of theory, and their step height is equal to that of a unit cell, showing that these are growth spirals originating from screw dislocations.

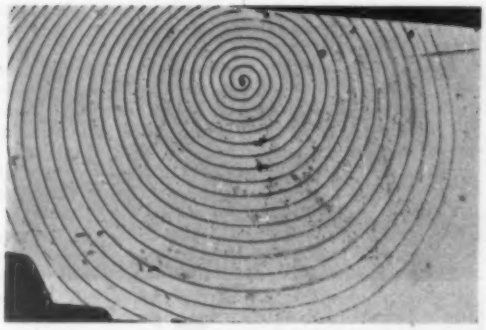
A more detailed account of this work has been communicated elsewhere. I am grateful to Prof. S. Tolansky for his interest and encouragement in the course of this work, and to the British Council for the award of a scholarship.

Ajit Ram Verma

Royal Holloway College,
Englefield Green,
Surrey.

[1] Burton, Cabrera and Frank, *Nature*, **163**, 398 (1949).
[2] Frank, F. C., Farad. Soc. Discuss., Crystal Growth, No. 5 (1949).
[3] Griffin, L. J., *Phil. Mag.*, **41**, 196 (1950).
[4] Ramsdell, L. S., *Amer. Min.*, **32**, 64 (1947).
[5] Tolansky, S., "Multiple-beam Interferometry of Surfaces and Films" (Oxford Univ. Press, 1948).
[6] Mellor, J. W., "A Comprehensive Treatise on Inorganic and Theoretical Chemistry", **5**, 879 (1924).

The theory of crystal growth based on dislocation theory as formulated by F. C. Frank[1] predicts the presence of growth features in the form of very flat, spirally terraced hills on the crystal face which is perpendicular to a screw dislocation line.



The only experimental evidence so far in favour of this theory is a picture of a beryl prism face made by L. J. Griffin[2]. We present here new and further evidence supporting Frank's point of view, in the form of a picture of a growth spiral on a carborundum (0001) face (see photograph). Although Frank's theory was specially conceived for crystals growing from the vapour phase, it was already thought to hold for growth from solution too. It seems established now that it applies to growth from the melt as well, since carborundum is grown in that way.

Applying the same technique of observation as L. J. Griffin, we deposited a thin, highly reflecting silver film on the faces to be examined. This method increases the visibility of very small surface steps without altering their heights or introducing false detail. Moreover, one has the additional possibility of using the silvered face afterwards as one component of a multiple-beam interferometer, the other being an optical flat, and so evaluating the step heights and surface angles with great accuracy[3].

We observed both spirals consisting of probably unimolecular steps and spirals having step heights up to 35 A. For illustration here, a photograph of a spiral of the last type was used, since the quality of the picture was better in this case. The form of all the spirals, however, was the same. The first loops slightly follow the hexagonal symmetry of the crystal face. The spacings between the successive loops gradually increase, the law being very approximately linear. The velocity of radial growth must consequently be an increasing function of the radius of curvature, as foreseen by theory, at least for not too large values of the radius of curvature.

Most of the faces investigated showed but one spiral covering the whole area, which seems to prove that carborundum crystals must be extremely perfect. Some faces contained more than one growth spiral, showing interaction of the type predicted by theory.

A more detailed account of the observations, and of the multiple-beam interference measurements referred to, will be published elsewhere.

We are very much indebted to Prof. W. Dekeyser for suggesting this investigation. This work is part of a research scheme supported by the Centre National Belge de Chimie Physique Moleculaire, to which I am indebted for a research fellowship.

S. Amelinckx

Crystallographic Laboratory,
Geological Institute,
University of Ghent.

[1] Frank, F. C., Farad. Soc. Discuss. No. 5, 48 (1949).
[2] Griffin, L. J., *Phil. Mag.*, (7), **41**, 196 (1950).
[3] Tolansky, S., "Multiple-Beam Interferometry of Surfaces and Films" (Oxford Univ. Press, 1948).

Growth of Large Quartz Crystals

During recent years there has been considerable interest both in Europe and the United States in the synthesis of quartz crystals large enough for use as piezo-electric oscillators in telecommunication equipment. An isothermal process for growing such crystals was described by Nora and W. A. Wooster[1] in 1946 and a similar method was developed independently in Germany during the Second World War by Nacken[2]. The isothermal process depends on the high solubility of silica glass relative to that of α-quartz under hydrothermal conditions. In our most successful experiments we were able to deposit a total of nearly 1 mm. of good-quality quartz on to a seed crystal, cut parallel to a rhombohedral face, in an 18-hr. growth-cycle. However, difficulties were incurred in attempting to prolong the growth-cycle beyond a day, due to the devitrification of the silica glass[3]. We therefore re-examined alternative methods employing a temperature gradient, such as Spezia[4] used in his pioneer experiments.

Spezia employed an autoclave with a hot zone at the top containing crushed quartz as source material, the seed crystals being placed in the cooler zone at the bottom. In 1948, Hale[5] found it convenient to reverse this arrangement, so that the autoclave was heated from its base and the temperature decreased upwards. Both Hale[6] and Walker[7] have obtained substantial success in growing sizable crystals of quartz, for the most part using seeds cut parallel to a rhombohedral face. On the other hand, using seeds cut parallel to the basal plane (0001), they report poor-quality growth until the pyramidal caps are complete. Thereafter quartz of sound quality is deposited on the newly formed rhombohedral faces.

The temperature-gradient process which we have developed employs an experimental arrangement which is broadly similar to that described by Walker, but there are significant differences. We have employed a cylindrical steel autoclave with an internal bore of 5 cm. diameter and 25 cm. depth corresponding to a capacity of about 450 ml. The autoclave is charged with an aqueous solution of sodium carbonate with crushed quartz placed loosely in the bottom and seed crystals suspended from the lid. The autoclave stands on a hotplate, and the furnace lagging is such that there is a temperature drop of 40° C. over its entire length. Sufficient liquid is put into the autoclave to produce, at the working temperature of 360–400° C., a pressure between 1,000 and 2,000 atmospheres. We have established the conditions which control the rate of growth on seeds cut parallel to (0001), and many successful runs have been carried out in which good-quality quartz has been deposited at a rate of 0·35 mm./day on each (0001) face. In recent runs we have increased the rate of deposition to 0·5 mm./day, giving a total thickness increase of 1 mm./day, and still obtained quartz of good quality.

Although the main growing surface is not planar, the quality of the quartz deposited is of the same high quality as the best Brazilian quartz. This is interesting both because (0001) is rarely found in Nature, and Walker and Hale, as mentioned above, report only bad-quality growth in the material capping the crystal. The synthetic crystals which we have grown on seed plates parallel to (0001) have a habit which is suitable for the economical fabrication of oscillator plates. We illustrate this point by the accompanying photograph, which shows a synthetic crystal weighing 15 gm. grown on to a 2-cm. square (0001) seed plate, the weight of which was originally 2 gm. The length

along the *c*-axis of the seed was originally 2 mm. and the final crystal was 16 mm. long. Such crystals may readily be grown in two to four weeks. In general, they are completely free from cracks, inclusions and twinning.

A comparison has been made of the values of some physical properties in the new synthetic crystals and in natural first-grade Brazilian quartz crystals. We find no difference in the refractive indices of the two materials within the limits of accuracy of our measurements, $\pm$ 0·0002. The lattice spacings agree within the normal limits of accuracy of X-ray powder photographs (that is, 1 in 5,000), and the crystalline texture of the synthetic quartz is shown by X-ray methods to be comparable with the best found in Nature. A number of X-cut oscillator bars, of frequency about 200 kc./s. (thickness parallel to a diad axis), have been cut from a synthetic crystal and mounted in standard holders. Their performance as oscillators is quite as good as that of a control group of similar bars cut from Brazilian quartz.

The experiments show that the mass of quartz which can be deposited in a given time increases with the area of the seed plate; but this area is naturally limited by the size of the autoclave. It is possible with our present autoclaves to employ seed plates 3 cm. square, and in this way synthetic crystals weighing about 80 gm. can be grown in a month.

It is a pleasure to acknowledge the help and advice accorded to us by Mr. J. W. Ryde throughout the course of this investigation. The work has been carried out for the Ministry of Supply under the auspices of the Inter-Service Radio Components Research and Development Committee, and we are grateful for the Committee's permission to publish this letter.

C. S. Brown
R. C. Kell
L. A. Thomas
Research Laboratories,
The General Electric Co., Ltd.,
Wembley, Middlesex.

Nora Wooster
W. A. Wooster
Brooklyn Crystallographic
Laboratory, Cambridge. Feb. 8.

[1] Wooster, Nora, and Wooster, W. A., *Nature*, **157**, 297 (1946).
[2] Nacken, R., F.I.A.T. Final Report No. 641, 11 (1945).
[3] Thomas, L. A., Wooster, Nora, and Wooster, W. A., Farad. Soc. Discus. No. 5, 341 (1949).
[4] Spezia, G., *Atti. R. Acad. Sci. Torino*, **41**, 158 (1906).
[5] Hale, D. R., *Science*, **107**, 393 (1948).
[6] Hale, D. R., Farad. Soc. Discuss. No. 5, 189 and 363 (1949).
[7] Walker, A. C., and Beuhler, E., *Indust. and Eng. Chem.*, **42**, 1369 (1950).

Source Points of Radio Noise Bursts associated with Solar Flares

Sudden large increases of radio noise on metre wave-lengths have been reported by many workers at the times of intense solar flares[1,2].

Hey, Parsons and Phillips[3] have shown the existence of a delay, amounting to several minutes, between the time of the flare 'flash' and the time of onset of the noise burst on 73 Mc./s. for a number of flares visually observed at Greenwich and Sherborne. Payne-Scott, Yabsley and Bolton[4] have reported that on such occasions the successive delays on 200, 100 and 60 Mc./s. show an increase with decreasing radio-frequency. Since the electron density is a decreasing function of height in the solar atmosphere according to Baumbach[5], it has been assumed by Martyn[6] and others that the radiations of high frequency (centimetre-band) originate near the solar photosphere and those of lower frequency (metre-band) at increasing heights in the corona. It has therefore been suggested[4] that the delays may arise from the successive excitation of levels at increasing heights by the outward motion of some disturbing agency having a velocity of the order of several hundred kilometres per second. Such an agency, for example, expelled at the moment of the flare flash with a uniform speed of 200 km./sec., would reach a height of 100,000 km. in 8 min., which is the order of the delay times actually recorded.

Reber[7] has listed the delayed starting times of the noise bursts associated with a flare on July 12, 1950. Eight different frequencies were recorded within the range 9,500–25 Mc./s. Relating each starting time to an appropriate height in the corona, he infers that the exciting disturbance rose to a height of 310,000 km. and then *fell back* towards the chromosphere. Velocities of the order of 500 km./sec. were indicated over a period of 16 min.

By a remarkable development of radio interferometry, Payne-Scott and Little[8] have been able to follow directly the motion of one of the source points of these radio emissions on a frequency of 100 Mc./s. In the case quoted, the source of the radio waves was followed outwards with their receiver from a visually observed flare near the sun's limb to an apparent height of 500,000 km., the travel time being 30 min. This gives a mean velocity across the line of sight of nearly 300 km./sec. Their graph also shows that the source point was subject to a *retardation* during its ascent.

The question may now be put: Can these radio phenomena be related to any characteristic visible disturbance associated with intense flares when these are observed by light of the Hα line? Eruptive prominences observed simultaneously with flares were first reported by Giovanelli[9], and their peculiar motions have been very fully investigated by H. W. Newton[10] and by me[11]. They appear suddenly, within a few minutes of the time of peak intensity of a nearby flare, and move outwards nearly normally to the sun's surface at initial speeds up to 500 km./sec. They are subject to a *retardation*, sometimes exceeding the value of solar gravity (28 g), which brings the moving particles to rest at the top of their trajectory in the region of 1–5 $\times$ 10^5 km. above the photosphere. Part, at least, of the material falls back towards the chromosphere before its luminosity fades away. I have called such prominences 'flare surges'. They are observed in association with 80 per cent of the more intense flares of Class 3 and 3$^+$. Their behaviour

is in contrast to the predominant downward motion of other prominence types but coincides with the characteristic motions of the 'surges', first discovered at the McMath–Hulbert Observatory. Surges have also been strikingly recorded in the films of solar phenomena taken by Menzel and Roberts at Climax.

There is, therefore, a remarkable similarity between the observed motion of the flare surges and the deduced motion of the radio noise source-points. It is suggested that this outward blast of particles, ejected possibly by the pressure of $L\alpha$ radiation in the flare flash, sets up turbulence and plasma oscillations in the ionized medium above the seat of the flare. These turbulent motions would generate radio waves of the observed frequencies. The visible column of material, which emits Hα light, may form only a small fraction of the total matter expelled at these times: if the remainder is ionized it will be unobservable in the spectrohelioscope.

Clearly, it is important to try to link up the two sets of phenomena by simultaneous observations in the radio and visible wave-bands during the course of a single flare.

Note added in proof. A paper by J. P. Wild[13], dealing with the radio spectrum of these outbursts, has just come to hand. They are tentatively ascribed to the outward passage from the flare of particles which, in favourable circumstances, reach the earth about a day later, causing terrestrial magnetic storms.

M. A. Ellison

Royal Observatory,
Edinburgh 9. April 23.

[1] Hey, J. S., *Nature*, **157**, 47 (1946).
[2] Appleton, E., and Hey, J. S., *Phil. Mag.*, **37**, 73 (1946).
[3] Hey, J. S., Parsons, S. J., and Phillips, J. W., *Mon. Not. Roy. Astro. Soc.*, **108**, 354 (1948).
[4] Payne-Scott, Ruby, Yabsley, D. E., and Bolton, J. G., *Nature*, **160**, 257 (1947).
[5] Baumbach, S., *Ast. Nach.*, **263**, 121 (1937).
[6] Martyn, D. F., *Nature*, **159**, 26 (1947).
[7] Reber, G., *Science*, **113**, 312 (1951).
[8] Bracewell, R. N., *The Observatory*, **70**, 185 (1950).
[9] Giovanelli, R. G., *Astrophys. J.*, **91**, 334 (1940).
[10] Newton, H. W., *Mon. Not. Roy. Astro. Soc.*, **102**, 2 (1942).
[11] Ellison, M. A., *Mon. Not. Roy. Astro. Soc.*, **102**, 11 (1942); **109**, 15 (1949); *Nature*, **165**, 749 (1949); and unpublished material.
[12] Wild, J. P., *Aust. J. Sci. Res.*, A, **3**, 399 (1950).

Radium and Deep-Sea Chronology

Collaboration between Austrian, Norwegian and Swedish specialists gave the first accurate measurements of the content of uranium and radium in sea water[1]. These results have recently been confirmed by measurements on much more extensive material collected during the Swedish Deep-Sea Expedition[2]. Whereas uranium remains fairly constant (average content $1{\cdot}3 \times 10^{-6}$ gm. per litre), the radium content is more variable, averaging about $0{\cdot}07 \times 10^{-12}$ gm. per litre or 15 per cent of the theoretical value in equilibrium with the dissolved uranium. I have suggested that this lack of radium in ocean waters is due to precipitation of its parent element ionium together with ferric hydroxide[3]. This would also explain the surprisingly high radium content found in the surface layer of red clay and radiolarian ooze as ionium-supported radium, decreasing downwards with the half-period of ionium, 83,000 years. Such a falling-off in radium content was first demonstrated in long cores by Piggot and Urry[4], and has been used in their attempts to estimate the rate of sedimentation.

Attempts made here and in the Institut für Radiumforschung in Vienna to apply the same method to age-determinations in cores from the *Albatross* cruise have not given such smooth curves as those published by Urry. The radium content often varies irregularly with 'depth' below the surface of the sediment, indicating that secondary processes like diffusion, adsorption, etc., interfere with the regular distribution of radium to be expected from the decay of ionium *in situ*. Approximate age determinations have, however, been made by this method applied to some of our cores from the Atlantic and the Central Pacific Ocean.

Another method of determining the rate of sedimentation from radium measurements is the following. From the amount of uranium-produced ionium in sea water precipitated on to the sea bottom from a water column of given height, a theoretical maximum value of the radium in equilibrium with this ionium, attained after about 10,000 years, can be found. Comparing this theoretical value with that found by measurements, the dilution due to non-active components and hence their rate of sedimentation can be found.

A detailed analysis for radium made on thin sections from the uppermost part of a core taken about 240 miles north of Tahiti (lat. 13° 25′ S., long. 149° 30′ W., depth of water 4,630 m.) gave a rather diffuse maximum of 50×10^{-12} gm. radium/gm., situated about 1 cm. below the surface of the sediment. Comparing this with the maximum value of radium carried by ionium to be expected from the precipitation of ionium from the superposed water column, the dilution with fresh sediment is found to require a sedimentation-rate of about 0·5 mm. in a thousand years. Allowing for the spread of radium from the theoretical maximum as indicated by the measurements, a 20 per cent higher maximum value and a corresponding reduction in the rate of sedimentation to about 0·4 mm. in a thousand years would follow. This is in good agreement with the rate of sedimentation derived from the general falling-off in radium content within the uppermost 15 cm. of the same core, namely, 0·4 mm. in a thousand years.

The method here described obviously gives a value for the 'actual' rate of sedimentation, if by 'actual' is meant the average value for the past ten thousand years. The results emphasize the importance of collecting cores from deep-sea sediments with as little disturbance of the uppermost top layer as possible, and of submitting this layer to detailed analysis for radium. The same method is now being applied also to other cores with varying rates of sedimentation, and corresponding variations of radium content in the layer of maximum concentration. Details will appear in the Reports of the Swedish Deep-Sea Expedition, to be published by the Royal Society of Gothenburg.

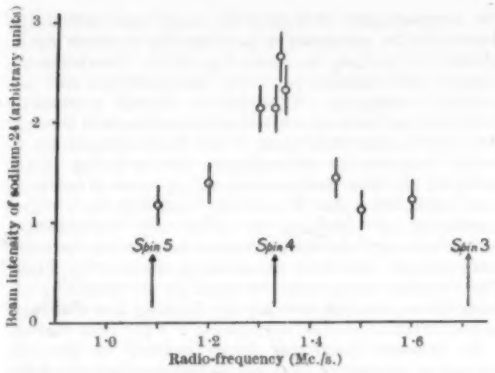
Hans Pettersson

Oceanografiska Institutet,
Göteborg. March 20.

[1] Pettersson, H., *et al.*, *Medd. Oc. Inst.*, No. 2 (1939).
[2] Koczy, G., *Mitt. Inst. Radiumforschung*, 463 (Vienna, 1950).
[3] Pettersson, H., *Wiener Anzeiger*, 1 (1937).
[4] Piggot, C. S., and Urry, Wm. D., *Amer. J. Sci.*, **240**, 1 and 93 (1942).

Spin of Sodium-24

An atomic beam apparatus using magnetic resonance[1] has been built and used for finding the spin of sodium-24. The focusing magnets and the radio-frequency section are similar to those used by Davies[2] for studying the spin and hyperfine structure of sodium-22. The intensity of the sodium-24 beam was found by collecting on a target and afterwards measur-



ing the activity of the sodium-24 deposited. The sodium-24 was produced by irradiating metallic sodium with slow neutrons in the pile at Harwell; thanks are due to the Isotope Division there for the repeated irradiations.

The result of one run is shown in the accompanying diagram; a second run gave the same location for the resonance maximum. The homogeneous magnetic field was adjusted so that sodium-23, which has a spin of 3/2 units, produced a resonance at 3·00 Mc./s. At the low value of magnetic field used (~ 4 gauss), the resonance frequency is inversely proportional to $2I + 1$; the expected locations of the resonances for spins of 3, 4 and 5 units are shown on the diagram. The resonance maximum for sodium-24 clearly lies at 1·33 Mc./s., so the spin of sodium-24 is 4 units.

The measurements are to be extended to higher magnetic fields to find the magnetic moment as well.

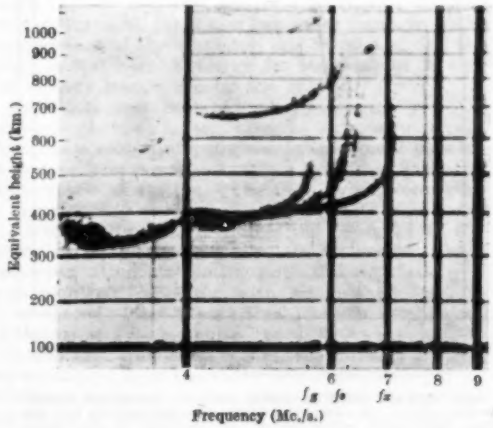
K. F. Smith

Cavendish Laboratory,
Cambridge. April 26.

[1] Zacharias, J. R., *Phys. Rev.*, **61**, 270 (1942).
[2] Davies, jun., L., M.I.T. Tech. Report No. 88.

Polarization of the Z-Trace

The appearance in northern Canada of the third critical frequency (Z-trace) in radio-wave vertical-incidence reflexions from the ionosphere has been a fairly common occurrence since it was reported by Meek[1].



An experiment carried out at Fort Chimo (lat. 58·1° N., long. 68·3° W.) on September 30, 1950, showed the polarization of the Z-trace to be ordinary, or in the northern hemisphere, anticlockwise as viewed in the direction of propagation. This is compatible with the theory that the Z-trace is the longitudinal ordinary reflexion (made possible at off longitudinal directions by the effect of collision[2]), rather than an earlier view that it is the second extraordinary reflexion.

The Z-trace appeared as shown in the accompanying photograph at 0900 hr. E.S.T. and persisted in great strength until 1100 hr. Polarization measurements were made continually during this period near the $F2$ critical frequency (about 6 megacycles) on a phase-shift and suppression-type equipment built by Mr. J. W. Cox and Mr. D. R. Hansen.

J. E. Hogarth

Radio Physics Laboratory,
Defence Research Board,
Ottawa, Ontario.

[1] Meek, J. H., *Nature*, **161**, 597 (1948).
[2] Scott, J. C. W., *J. Geophys. Res.*, **55**, 65 (1950).

Yield Phenomenon and Twinning in α-Iron

Iron containing small amounts of carbon and nitrogen exhibits a peculiar relationship between stress and strain which appears in different forms at different temperatures; it shows the yield phenomenon at room temperature, blue brittleness at temperatures in the range 200–400° C., and twinning at the temperature of liquid air. The part played by the carbon and nitrogen in the yield phenomenon has been explained by a recent theory[1–3] according to which certain foreign atoms in the metal collect preferentially at dislocations. Blue brittleness occurs when the temperature and strain-rate are such that strain ageing can occur during the time needed for a Lüders band to travel along the specimen. This causes repeated yielding to take place.

The question of whether single crystals of iron show the yield phenomenon, as is required by the dislocation theory, has been controversial for many years; certainly they do not show the strongly marked yield that is typical of fine-grained iron. Recently, using a rigid tensile testing machine and 2-mm. diameter wire specimens, we have observed yield points in lightly carburized 'Armco' iron single crystals (0·02 per cent carbon)[4] (see Fig. 1,*a*), and very similar results have been obtained independently by Schwarzbart and Low[5] in America. In these experiments, which were conducted at room temperature, a marked fall in stress at the yield point was not observed.

We now find that, by lowering the testing temperature to — 77° C. (acetone/dry-ice mixture), the yield point in the single crystals becomes more marked and a sharp fall in stress from 18,000 lb. per sq. in., at the upper yield point, to 15,000 lb. per sq. in., at the lower yield point, is observed. Under these conditions the yield elongation is about 1½ per cent (see Fig. 1,*c*).

On lowering the testing temperature to that of liquid air (— 190° C.) the yield phenomenon is replaced by deformation twinning. Carburized single crystals of 'Armco' iron (0·02 per cent carbon) twinned at stresses between 40,000 and 50,000 lb. per sq. in.

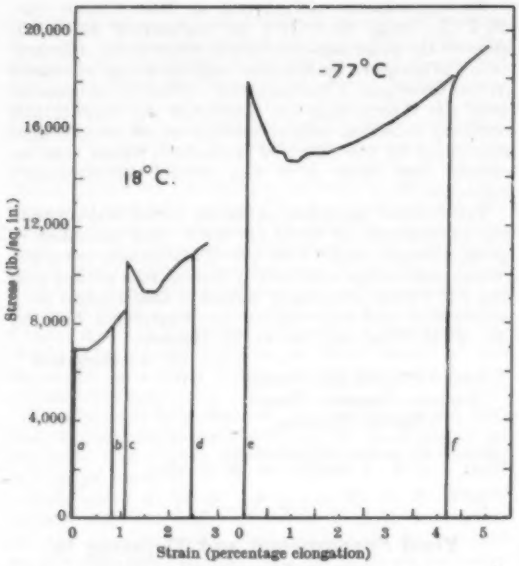


Fig. 1. Carburized 'Armco' iron single crystals (0·02 per cent carbon) tested at room temperature and −77° C.

Room temp. { (*a*) First test; (*b*) Immediate reload; (*c*) Retest after strain ageing for 18 hr. at 18° C.; (*d*) Immediate reload } −77° C. { (*e*) First test; (*f*) Immediate reload }

in liquid air. The twinning was indicated by a series of sudden falls in stress of 250–25,000 lb. per sq. in., which were accompanied by clearly audible clicks (see Fig. 2,*a*). The crystals eventually broke by cleavage fracture after a total extension of less than 3·0 per cent. Twinning could also be produced in single crystals by impact loading at room temperature. On the other hand, twinning could not be produced in coarsely polycrystalline specimens at the temperature of liquid air; these fractured at the grain boundaries at stresses of 35,000–40,000 lb. per sq. in.

Polished and etched (4 per cent 'Nital') sections of the crystals tested in liquid air showed four sets of twin bands, of which only one was prolific. These bands were identified by X-ray back-reflexion photographs as twins on four different {112} planes, whereas the surface of cleavage consisted of {100} facets.

It is well known that the yield point of iron can be removed permanently by eliminating the carbon and nitrogen from the metal, or removed temporarily by plastic deformation; in the latter case it returns after the metal has been aged. We now find that twinning is affected in the same way. Thus a thoroughly decarburized and denitrided crystal (2 mm. diameter, annealed at 720° C. for 120 hr. in wet hydrogen) was observed to deform by slip instead of twinning at the temperature of liquid air, and was sufficiently ductile to be extended 6 per cent by stresses up to 55,000 lb. per sq. in. (see Fig. 2,*b*); furthermore, impact deformation at room temperature did not produce twinning. Similarly, a crystal containing 0·02 per cent carbon, which had been strained through the yield point (less than 1 per cent elongation) at room temperature immediately before being tested in liquid air, then deformed by slip instead of twinning and extended some 9 per cent (see Fig. 2,*c*). This inhibiting of twinning by prior slip deformation, which was also shown by impact tests made at room temperature, has been observed previously by Pfeil[6]. The corresponding improvement in the ductility has been demonstrated recently by Ripling and Baldwin[7] in polycrystalline steel containing 0·4 per cent carbon.

It appears that the stress needed to produce twinning, as well as that needed to produce the yield phenomenon, is increased by a strain-ageing treatment. Thus, a crystal containing 0·02 per cent carbon which was first strained about 1 per cent at room temperature, and then aged for 1 hr. at 110° C., deformed purely elastically when tested in liquid air up to the limit of the apparatus, that is, up to a stress of 57,000 lb. per sq. in. (see Fig. 2,*d*), although it could be made to twin by impact deformation at room temperature. The return of the ability to twin after ageing has been demonstrated earlier by Pfeil[6] on iron crystals of unspecified composition.

These results raise two questions. First, why is there a more pronounced fall in stress at the yield point when the experiment is made at − 77° C. instead of room temperature, and second, why is twinning so closely related to the yield phenomenon? These effects could both be explained on the basis of the unusually steep dependence of the upper yield stress on temperature[3]. In the first place, the upper yield point will stand further above the level of stress required to maintain plastic flow the lower is the temperature of testing. Secondly, this upper

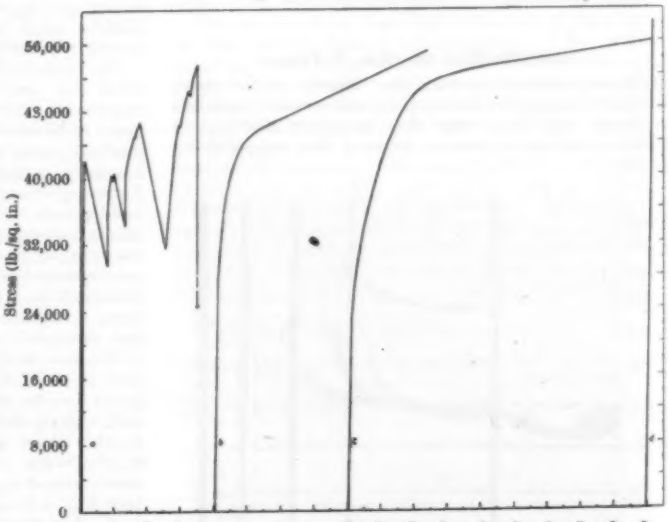


Fig. 2. 'Armco' iron single crystals tested in liquid air. (*a*) Carburized crystal. (*b*) Carbon- and nitrogen-free crystal. (*c*) Carburized crystal after pre-straining by 1 per cent at room temperature immediately before testing. (*d*) Specimen (*c*) after strain ageing for 1 hr. at 110° C.

yield stress can rise so high at low temperatures or at fast rates of straining (for example, impact deformation at room temperature) that it will exceed the twinning stress, and so the specimen will deform by twinning. On the other hand, in a crystal in which the yield phenomenon has been removed by purification or by plastic deformation, the elastic limit for slip will not depend so sensitively on temperature[8,9] or strain velocity, and in consequence will not exceed the twinning stress. Finally, we may note that the comparative brittleness shown at low temperatures, or at high rates of strain, of specimens that possess yield points lends support to Orowan's theory of brittle fracture[10], which requires an unusually steep dependence of yield stress on temperature and rate of strain.

We wish to thank Prof. D. Hanson, director of the Department of Metallurgy, for his encouragement and support, and the University of Birmingham for provision of facilities and financial support.

A. T. Churchman
A. H. Cottrell

Department of Metallurgy,
University,
Birmingham.
Jan. 26.

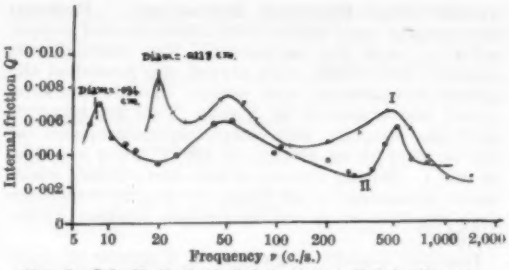
[1] Cottrell, A. H., Rep. Bristol Conf. Strength of Solids, Phys. Soc. London, 30 (1948).
[2] Nabarro, F. R. N., Rep. Bristol Conf. Strength of Solids, Phys. Soc. London, 38 (1948).
[3] Cottrell, A. H., and Bilby, B. A., *Proc. Phys. Soc.*, A, **62**, No. 4, 49 (1949).
[4] Cottrell, A. H., and Churchman, A. T., Discussion, *Trans. Amer. Inst. Min. Met. Eng.*, **185**, 887 (1949).
[5] Schwarzbart, H., and Low, J. R., *J. Metals*, **1**, No. 9, 637 (1949).
[6] Pfeil, L. B., Carnegie Schol. Memoirs, **15**, 319 (1926).
[7] Ripling, E. J., and Baldwin, W. M., *Amer. Soc. Met.*, Preprint 24 (1950).
[8] Orowan, E., *Z. Phys.*, **89**, 634 (1934).
[9] Mott, N. F., and Nabarro, F. R. N., Rep. Bristol Conf. Strength of Solids, Phys. Soc. London, 1 (1948).
[10] Orowan, E., *Trans. Inst. Eng. and Shipbuilders in Scotland*, Paper No. 1063, 166 (1945).

Relaxation Spectrum of Glass

Relaxation spectra for different kinds of glass, all containing sodium and potassium as common constituents, have been obtained from lateral vibrations over a frequency-range from 5 to 1,500 c./s. It has been found that, in addition to relaxation by thermo-elastic currents, the internal friction at room temperature (26° C.) shows two other common peaks independent of the diameter, one at 50 c./s. and the other at 500 c./s. Evidence for the peak at 50 c./s. has already been given by one of us[1].

Vibration was detected photo-electrically. On account of the finite, though extremely small, electrical conductivity of glass, it was found possible to induce transverse vibrations in glass fibres by electrostatic excitation. The fibre, when connected to a polarizing voltage of the order of 1,000 volts to ground, ultimately acquires the potential of the source in about one minute. If an exciter plate, connected to an alternating potential supplied by a beat-frequency oscillator with an earthed lead, is situated near the glass fibre, forced mechanical vibrations will be set up.

In the high-frequency region, the internal friction was calculated from the width of the resonance curve. In the low-frequency region it was estimated from the free decay of amplitude.



Glass I. SiO_2 68, Na_2O 18, CaO 6, Al_2O_3 4, K_2O 2, other constituents 2.
Glass II. SiO_2 70, Na_2O 11, Al_2O_3 10, K_2O 6, other constituents 3

Typical results are given in the accompanying graph. The first peak in each case is identified with that arising from diffusion of thermo-elastic currents. The theoretical value is indicated by a vertical line. The constitution of the specimens investigated indicates that ionic diffusion of sodium and potassium appears to be responsible for this type of relaxation.

Y. L. Yousef
R. Kamel

Physics Department,
Faculty of Science,
Fouad I University,
Cairo.
Jan. 22.

[1] Kamel, R., *Phys. Rev.*, **75**, 1606 (1949).

X-Ray Study of the Thermal Decomposition of Dolomite

The thermal decomposition of dolomite has repeatedly been investigated; but the mechanism of this reaction still remains obscure. Some authors suppose that solid solutions of carbonates are formed during decomposition[1], others assume primary dissociation into separate carbonates[2] or into oxides[3] of magnesium and calcium. However, the fact that thermal decomposition takes place in the two stages (i) and (ii) has been generally established.

$$MgCa(CO_3)_2 \rightarrow MgO + CO_2 + CaCO_3 \quad \text{(i)}$$

$$CaCO_3 \rightarrow CaO + CO_2 \quad \text{(ii)}$$

The second step involves the decomposition of calcium carbonate, which occurs in the same way as that of natural calcite. Therefore, in order to obtain further information on the reaction mechanism, a detailed X-ray study of the first stage of decomposition was carried out using single crystals of dolomite.

Depending on temperature and partial pressure of carbon dioxide, dolomite can be decomposed either to magnesium oxide and calcium carbonate, or completely to magnesium and calcium oxides. Three series of experiments were carried out, at 600°, 640° and 800° C., the partial pressure of carbon dioxide being 100, 100 and 650 mm. respectively in order to effect only stage (i) of the reaction. For studies of complete decomposition, the partial pressure of carbon dioxide was lowered to 0·02 mm.

Needles about 3 mm. long and 0·5 mm. in diameter were prepared by cleaving pure transparent dolomite

crystals (from Binnental, Switzerland). Rotation photographs were taken with nickel-filtered copper radiation, and the asymmetric film method was applied. Afterwards, each crystal was heated at the desired temperature and carbon dioxide pressure, cooled, and examined by X-rays. This was repeated until the dolomite was completely decomposed (at 600° C. after about 300 hr., at 800° C. after less than 30 min.). During decomposition, the crystals maintained their shape in all details, so that no difficulties were experienced in taking further rotation photographs.

Initially, perfect single-crystal diagrams of dolomite were obtained. During decomposition the dolomite patterns gradually decreased in intensity, becoming, however, even more distinct. This indicates that the reaction proceeds from the surface to the interior of the crystal, an ever-decreasing dolomite kernel remaining. The state of order in the residual dolomite lattice was found to be perfect, and no signs of lattice distortions preceding the decomposition could be detected. Simultaneously the reaction products, magnesium oxide and calcium carbonate, were shown up in the rotation photographs. The width, homogeneity and intensity of the magnesium oxide powder patterns indicated crystallites between 10^{-5} and 10^{-4} cm. in size. These were not oriented, and no lattice distortions were present to any appreciable extent. It is most remarkable that the calcite formed by decomposition at 600° and 640° C. gave predominantly single-crystal patterns. These corresponded to those of normal calcite but indicated considerable lattice distortions. Further investigation showed that calcite was present as crystallites oriented exactly in the same way as the original lattice, thus resulting in a diagram equivalent to a calcite single crystal. Simultaneously, though with much less intensity, calcite powder patterns appeared. In certain cases even these exhibit a texture indicating some degree of orientation of the crystallites.

This striking orientation of calcite crystals can only mean that calcium carbonate is directly formed from the original dolomite. The transition of dolomite into the isotype calcite lattice is easily possible, as only replacement of magnesium and calcium ions and expansion of the lattice to less than 4 per cent are necessary. In small areas where a sufficient excess of magnesium ions has accumulated, magnesium oxide nuclei will be formed which will grow to crystallites by diffusion of metal ions. Simultaneously the dolomite lattice in neighbouring parts is gradually converted into a calcite lattice. In this process carbon dioxide developed from a carbonate ion may recombine with an oxygen ion of a neighbouring carbonate group which has already decomposed, and either remain there or diffuse further out of the crystal. Further growth of the crystallites is limited as the concentration of magnesium and calcium ions in their immediate vicinity decreases. At other parts of the reaction zone the same process takes place, so that finally the original dolomite crystal has a granular structure consisting of irregularly distributed magnesium oxide and of oriented calcium carbonate crystallites. This has been confirmed by microscopic observation under polarized light.

According to our experiments, there is no reason for assuming that the reaction mechanism is fundamentally different at high temperatures (for example, 800° C., 650 mm. pressure carbon dioxide). Under these conditions, most of the calcite crystals were no longer oriented to the original lattice, since the powder patterns now exceeded the few remaining single-crystal patterns very much in intensity. This is due to recrystallization of the primarily oriented calcite crystals, which are under considerable stress resulting from the transition of the dolomite into the calcite lattice.

Investigations on exchange of carbon-13 between dolomite and carbon dioxide at high temperatures carried out at the same time[4] are in good agreement with the reaction mechanism outlined above. Calcite has a higher reactivity *during* its formation from the dolomite lattice than after it has already been formed.

This communication is published by permission of the South African Council for Scientific and Industrial Research. A detailed account will appear elsewhere.

H. G. F. Wilsdorf
National Physical Laboratory,
R. A. W. Haul
National Chemical Research Laboratory,
South African Council for Scientific and Industrial Research,
Pretoria.
Jan. 27.

[1] Balkov, A. A., *J. Russ. Metallurg.*, **1**, 311 (1913). Gel'd, P. V., and Esin, O. A., *J. App. Chem. (Russ.)*, **22**, 240 (1949); *Chem. Abst.*, **43**, 6059 (1949).

[2] Potapenko, C. W., *Chem. J., Ser. B, J. App. Chem. (Russ.)*, **5**, 693 (1932); *Chem. Abst.*, **27**, 1996 (1933). Fagueret, M., *Bull. Soc. Fran. Min.*, **63**, 88 (1940). Schwob, Y., *Rev. des matériaux de construction*, No. 414 (1950); *C.R. Acad. Sci., Paris*, **224**, 47 (1947).

[3] Flood, H., *Kon. Norske Vidensk. Sel. Forh.*, **22**, 188 (1949); *Chem. Abst.*, **44**, 6243 (1950).

[4] Haul, R. A. W., Stein, L. H., and Louw, J. D., *Nature* [**167**, 241 (1951)].

Effects of Triphosphopyridine Nucleotide upon Oxygen Evolution and Carbon Dioxide Fixation by Illuminated Chloroplasts

The illumination of suspensions of chloroplasts always causes a very small and transient evolution of oxygen. The rate curve for this process has previously been measured[1] under anaerobic conditions by means of the phosphorescence quenching method of Franck and Pringsheim[2]. In continuation of this work, the influence on oxygen production of certain biologically important substances added to the chloroplast suspensions has been studied.

Washed chloroplasts which gave a high rate of oxygen production with 'Hill reagents' did not show a measurable increase in either the rate of oxygen evolution or in the total oxygen output if pyruvic acid, hexose diphosphate, or phosphoglyceric acid[3,4] was added. On the other hand, addition of any of these three substances to a crude cell-free macerate of spinach leaves greatly increased the evolution of oxygen upon illumination. Yields varied considerably with the plant material employed; the maximum

Table 1. Oxygen Liberated by Illuminated Suspensions of Crude Spinach Juice*

Addition†	Amount added (μmoles $\times 10^3$)	Yield of oxygen (mm.^{3} $\times 10^3$)	
		Blank	Experimental
Phosphoglyceric acid	5	1·9	8·6
Pyruvic acid	3	0·4	3·6
Hexose diphosphate	5	2·5	7·5
Triphosphopyridine nucleotide	0·007	0·05	0·17
" "	1·5	0·05	0·62

* Gas phase, nitrogen. Temperature, 10° C.
† *p*H adjusted to 6·8–7·0.

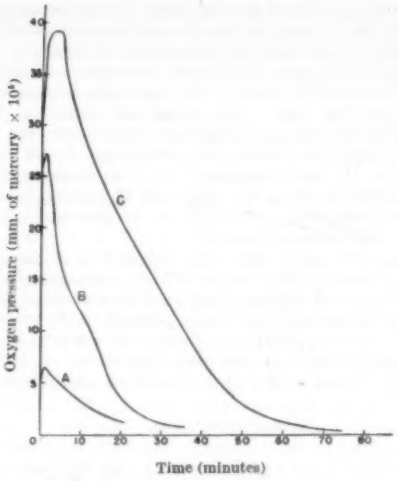


Fig. 1. Evolution of oxygen from 1·5 c.mm. crude spinach juice, containing 1·35 micrograms chlorophyll, to which has been added 1·5 c.mm. water (curve *A*); 1·5 c.mm. $2·5 \times 10^{-4}$ *M* triphosphopyridine nucleotide (curve *B*); and 1·5 c.mm. 5×10^{-4} *M* triphosphopyridine nucleotide (curve *C*). Flow rate: 9·7 c.c. nitrogen per min. Temperature: 12° C. Yields of oxygen: curve *A*, 0·01 c.mm.; curve *B*, 0·04 c.mm. (3,440 per cent); curve *C*, 0·13 c.mm. (76 per cent)

obtained was 16 per cent of the stoichiometric amount of oxygen (see Table 1). These results are consistent with at least two mechanisms: (*a*) the oxygen production is connected with a photochemical reduction of a hydrogen carrier present in the cell sap; the added compounds act as substrates which, by coupled reactions, re-oxidize the hydrogen carrier and thus increase the oxygen evolution; (*b*) the added substances are first transformed by cytoplasmic enzymes into intermediates which are then directly reduced at the chloroplasts.

Drs. E. Conn and B. Vennesland, of the Department of Biochemistry, University of Chicago, who have found the 'malic' enzyme[5] widely distributed in plants[6], suggested that the effect of adding their purified enzyme preparation and various components of the malic enzyme system be investigated. Addition of malic enzyme, triphosphopyridine nucleotide, manganous chloride, pyruvate and carbon dioxide to crude spinach juice greatly increased the oxygen production. However, exactly the same effect was achieved when only triphosphopyridine nucleotide was added (Table 1). This coenzyme acted catalytically on the oxygen evolution; addition of small amounts resulted in yields of oxygen thirty to forty times the equivalent of the added triphosphopyridine nucleotide (Fig. 1). Diphosphopyridine nucleotide also prolonged the evolution of oxygen at enhanced rates.

One of several possible explanations of these observations is consistent with the hypothesis proposed by Ochoa[7] (see also Conn, Vennesland and Kraemer, ref. 6) that pyridine nucleotides might be reduced photochemically by illuminated chloroplasts and that these reduced coenzymes could be utilized by enzyme systems for reductive fixation of carbon dioxide. To test this possibility directly, experiments with carbon-14 dioxide ($^{14}CO_2$) were carried out in collaboration with Dr. A. H. Mehler. In crude spinach juice to which the malic enzyme system had been added, the fixation of tracer carbon dioxide was found to be very large in the dark, and illumination gave only a slight increase. By using isolated chloroplasts, the dark reactions in the presence of the malic enzyme system were minimized. A markedly enhanced fixation of tracer carbon dioxide was then observed when the chloroplasts were illuminated (Table 2). Corresponding amounts of oxygen were evolved in parallel experiments (Fig. 2). However, it should be emphasized that the fixation of carbon dioxide and the evolution of oxygen from isolated chloroplast preparations to which the malic system had been added were small compared with the oxygen evolution obtained from crude spinach juice (with the same chlorophyll content) to which only triphosphopyridine nucleotide had been added.

Table 2. Carbon Dioxide Fixed by Isolated Chloroplasts and 'Malic' Enzyme System*

Additions	Counts per minute fixed	
	Dark	Light
Chloroplasts with 0·4 mgm. chlorophyll; 0·1 m.mole glycylglycine buffer, *p*H 7·4; 1·0 c.c. sodium bicarbonate, 0·1 *M*, sat. with 1 atm. carbon dioxide; tracer sol. with $2·4 \times 10^6$ counts/min.; 0·18 m. mole pyruvate; 10 μmoles manganese chloride; 0·5 μmole triphosphopyridine nucleotide; 0·47 c.c. malic enzyme (see legend Fig. 2)	540 ± 190	7,100 ± 250

* Incubation time, 30 min. at 18° C.

Drs. S. Ochoa and W. Vishniac, New York University, have recently observed a synthesis of malate by the malic enzyme system in illuminated chloroplast suspensions [personal communication. See *Nature*, May 12, p. 768.—Editors]. In view of the findings of the two laboratories, there is no doubt that pyridine nucleotides can be reduced by chloroplasts as the result of a light reaction, and that an enhanced fixation of carbon dioxide may occur. It is of interest that such a reduction of coenzymes having standard reduction potentials much lower than that of any known 'Hill reagent' can occur to a measurable extent. It would be premature, however, to conclude that these new findings represent a true model of

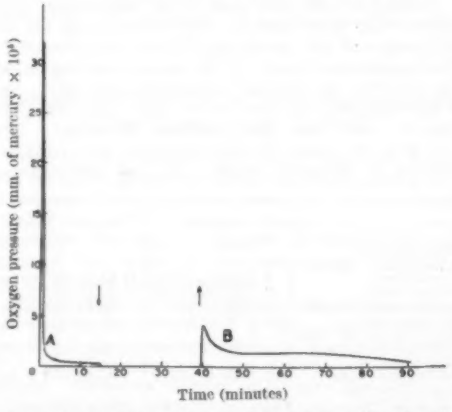


Fig. 2. (*A*) Evolution of oxygen from 3 c.mm. of a chloroplast suspension containing 1·8 micrograms chlorophyll, 0·04 micromoles manganese chloride, 0·4 micrograms triphosphopyridine nucleotide, 0·17 micromoles pyruvate, 0·08 micromoles glycylglycine buffer, *p*H 7·0. (*B*) At 21 min., 2 c.mm. malic enzyme (fraction *RP5C* described by Kraemer *et al.*, ref. 10) were added. Gas phase contained 4·2 per cent carbon dioxide and 95·8 per cent nitrogen. Flow rates: 8·8 c.c. per min. Temperature: 25° C. Downward and upward pointing arrows indicate light turned off and on, respectively

photosynthesis. Indeed, it has been pointed out[8,9] that normal photosynthesis cannot proceed via any mechanism which involves the photochemical reduction of substances present in concentrations small compared to that of chlorophyll.

L. J. Tolmach
Institute of Radiobiology and Biophysics
(Fels Fund),
University of Chicago,
Chicago 37, Illinois.
Jan. 26.

[1] Franck, J., *Rev. Mod. Phys.*, **17**, 112 (1945).
[2] Franck, J., and Pringsheim, P., *J. Chem. Phys.*, **11**, 21 (1943). Pollack, M., Pringsheim, P., and Terwoord, D., *J. Chem. Phys.*, **12**, 295 (1944).
[3] Calvin, M., and Benson, A. A., *Science*, **109**, 140 (1949). Benson, A. A., *et al.*, *J. Amer. Chem. Soc.*, **72**, 1710 (1950).
[4] Fager, E. W., Rosenberg, J. L., and Gaffron, H., *Fed. Proc.*, **9**, 535 (1950). Fager, E. W., and Rosenberg, J. L., *Science*, **113**, 617 (1950).
[5] Mehler, A. H., Kornberg, A., Grisolia, S., and Ochoa, S., *J. Biol. Chem.*, **174**, 961 (1948).
[6] Conn, E., Vennesland, B., and Kraemer, L. M., *Arch. Biochem.*, **23**, 179 (1949).
[7] Ochoa, S., in Green, D. E. (Ed.), "Currents in Biochemical Research" (New York, 1946). Ochoa, S., *Fed. Proc.*, **9**, 551 (1950). Ochoa, S., Veiga Solles, J. B., and Ortiz, P. J., *J. Biol. Chem.*, **187**, 863 (1950).
[8] Franck, J., Symposia Soc. Exp. Biol. (in the press).
[9] Tolmach, L. J., *Arch. Biochem.* (in the press).
[10] Kraemer, L. M., Conn, E. E., and Vennesland, B., *J. Biol. Chem.*, **188**, 583 (1951).

Deoxyribonucleic Acid Content of the Egg of *Sabellaria* during Maturation and Fertilization

There are at the present time no quantitative data on the deoxyribonucleic acid content of the individual gametes during maturation and fertilization. We have determined the deoxyribonucleic acid content of the egg of *Sabellaria*, from the first maturation division to the first segmentation division. As fertilization takes place before the first maturation division, both male and female components of the fertilized egg can be studied and compared.

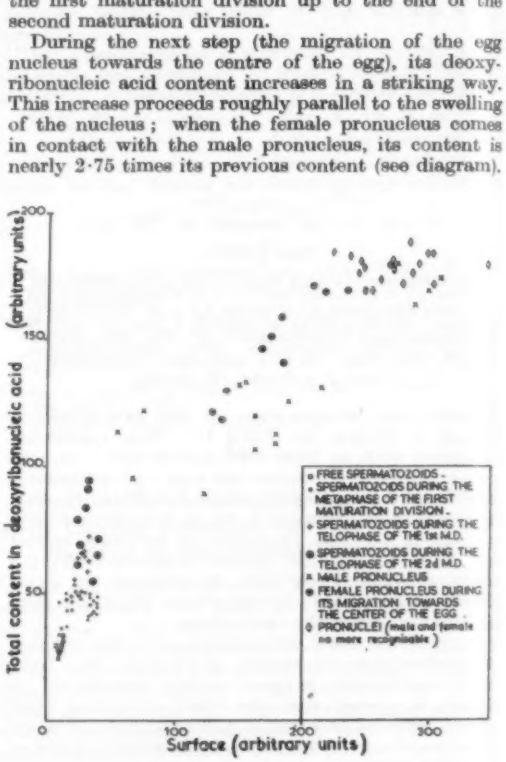
Measurements were made with the histophotometric apparatus of Lison[1] on Feulgen-treated material; the technique and the statistical treatment were identical with that used in a previous study on the development of the sea-urchin (Lison and Pasteels[2]).

The results are shown in the accompanying table, where n is the number of measured cells, $M \pm S_M$, $S \pm Ss$ respectively the mean and the standard deviation, each with its standard deviation. The values give the total deoxyribonucleic acid contents expressed in arbitrary units. In the last column, the values have been recalculated taking as unit the value for the young female pronucleus just after the completion of the second maturation division.

	n	$M \pm S_M$	$S \pm Ss$	
Female nuclei				
1st maturation division (metaphase)	4	257·00±6·82	13·64±4·82	3·98
1st polar body	17	127·47±2·89	11·94±2·04	1·97
2nd maturation division	2	129·50±1·59	2·25±1·12	2·00
2nd polar body	15	63·73±1·10	4·33±0·78	0·98
Mature egg (at the telophase 2nd mat. div.)	7	64·71±1·09	2·89±0·77	1·00
Male nuclei				
Free spermatozoids	26	29·34±0·71	3·61±0·50	0·45
During metaphase (1st mat. div.)	27	43·56±1·02	5·28±0·70	0·67
During telophase (1st mat. div.)	26	56·58±1·56	7·96±1·10	0·88
Pronuclei				
At conjugation	18	177·29±1·32	5·61±0·93	2·75
1st segmentation division				
Prophase	6	364·66±4·46	10·92±3·15	5·63
Metaphase	8	355·75±3·29	9·30±2·32	5·49
II Blastomeres				
Interphase	6	355·17±5·27	12·88±3·72	5·49

As expected, each of the two maturation divisions results in exactly halving the deoxyribonucleic acid content of the egg. The observed ratios of first metaphase to second metaphase to mature egg are 4 : 2 : 1, with deviation not exceeding 2 per cent. Therefore, no synthesis and no loss of deoxyribonucleic acid occur in the egg from the metaphase of the first maturation division up to the end of the second maturation division.

During the next step (the migration of the egg nucleus towards the centre of the egg), its deoxyribonucleic acid content increases in a striking way. This increase proceeds roughly parallel to the swelling of the nucleus; when the female pronucleus comes in contact with the male pronucleus, its content is nearly 2·75 times its previous content (see diagram).



A considerable synthesis of deoxyribonucleic acid occurs also in the male gamete. Quite unexpectedly, the content of the free spermatozoid is nearly the half of the content of the mature egg. After fertilization, its content increases (see diagram). During the maturation divisions, the increase bears no definite relationship to the swelling of the spermatic head. After the last maturation division, the increase proceeds roughly parallel to the swelling of the pronucleus. The synthesis of deoxyribonucleic acid in the male pronucleus and in the female pronucleus are not synchronous; differences up to 30 per cent have been observed between the contents of both pronuclei during their swelling. However, when the pronuclei come together in the centre of the egg, their content is now identical, the largest differences observed being well within the limits of experimental errors.

During the first division of segmentation, no further changes occur in the deoxyribonucleic acid content of the egg. The values found for the prophase and the metaphase are identical with the sum of those for the pronuclei. Each daughter-cell contains at

anaphase half the content of the metaphase. At the end of telophase, a new synthesis occurs. This doubles the content of each cell, so that each interphasic blastomere contains the same content as the whole preceding metaphase.

These observations permit the following conclusions. (1) Many authors, arguing from theory, have expressed the view that the deoxyribonucleic acid content of both gametes must be identical. The experimental evidence obtained from *Sabellaria* does not favour this view. (2) According to Boivin, Vendrely and Vendrely[3] and others, the deoxyribonucleic acid content of the (diploid) somatic cells must always be twice that of the (haploid) gametes, or in cases of polyploidy a simple multiple of this value. The values found from *Sabellaria* are very different from the theoretical ratios 1 : 2, or 1 : 4, 1 : 8, etc.; the ratio for spermatozoid to somatic cell (first blastomere) deoxyribonucleic acid is approximately 1 : 12, and that for mature egg to somatic cell is 1 : 5·5. (3) After fertilization, a considerable synthesis of deoxyribonucleic acid occurs in the spermatozoid and in the mature egg; the content of the spermatozoid is multiplied approximately six times, that of the egg approximately by 2·75. (4) In the course of the first segmentation division, the synthesis of nucleic acid occurs during late telophase. This is in accordance with our earlier finding on the synthesis of nucleic acid in the multiplying somatic cells[2,4].

J. Pasteels

Department of Embryology,

L. Lison

Department of Histology,
University of Brussels.
Jan. 26.

[1] Lison, L., *Acta Anatomica* (*Basel*), **10**, 333 (1950).
[2] Lison, L., and Pasteels, J., *Arch. Biol.*, **62**, 1 (1951).
[3] Vendrely, R., and Vendrely, C., *Experientia*, **5**, 327 (1949).
[4] Pasteels, J., and Lison, L., *Arch. Biol.*, **61**, 445 (1950).

Formation of Glycolaldehyde by Enzymic Scission of Pentoses

Fischler and Boettner[1] showed that pentoses can be split by alkali into glycolaldehyde and a triose. In the biochemical field, glycolaldehyde has been identified as a by-product in yeast fermentations, by Neuberg[2], who assumed that it arose via hydroxypyruvic acid.

Many micro-organisms of diverse types can attack one or more pentoses, and there is evidence that, when this occurs, the sugar is split into a triose and a molecule containing two carbon atoms[3–6]. During the breakdown of pentoses by a *Fusarium* species, Wirth and Nord[7] detected pyruvic acid in the metabolism solution and they assumed that the other scission product was glycolaldehyde. The suggestion that the latter substance is a product of the action of yeast on D-ribose-5-phosphate has been put forward by Dickens[8]. Glycolaldehyde has been isolated as its dimedone derivative, by Goepfert and Nord[9], from cultures of *Fusarium lini* Bolley on a medium containing ethylene glycol as the only source of energy.

Kaushal and Walker[10] showed that the oxidation of ethylene glycol by *Acetobacter acetigenum* similarly results in the formation of glycolaldehyde, which, in this case, was isolated as its 2 : 4-dinitrophenylosazone. Hitherto, however, the detection of glycolaldehyde during the utilization of pentoses or other sugars by micro-organisms has not been reported. We have now established the formation of glycolaldehyde by the action of *Acetobacter acetigenum* and related species upon the sugars D-xylose and L-arabinose.

Samples taken daily from cultures of these organisms developing at 30° C. upon media containing one or other of these pentoses as source of carbon showed, towards Fehling's solution, a reducing action which increased steadily to a maximum. At this stage addition of a solution of 2 : 4-dinitrophenylhydrazine in 2-*N* hydrochloric acid precipitated a red powder consisting of a mixture of substances. By fractionation with glacial acetic acid, a red compound which was almost insoluble in this solvent was isolated and was purified by crystallization from nitrobenzene and from chlorobenzene. It melted at 329° C. alone, or in admixture with the 2 : 4-dinitrophenylosazone from a sample of authentic glycolaldehyde which had been prepared from ethylene glycol by the method of Fenton and Jackson[11]. On combustion, the compound from the cultures gave figures for C, H and N in agreement with those calculated for the 2 : 4-dinitrophenylosazone of glycolaldehyde.

R. Kaushal
P. Jowett
T. K. Walker

Chemistry Department,
College of Technology,
Manchester 1.
Feb. 2.

[1] Fischler, F., and Boettner, R., *Z. physiol. Chem.*, **177**, 264 (1928).
[2] Neuberg, C., and Rosenthal, P., *Biochem. Z.*, **61**, 171 (1914).
[3] Fred, E. B., Peterson, W. H., and Davenport, A., *J. Biol. Chem.*, **39**, 367 (1919).
[4] Fred, E. B., Peterson, W. H., and Davenport, A., *J. Biol. Chem.*, **42**, 188 (1920).
[5] Challenger, F., Klein, L., and Walker, T. K., *J. Chem. Soc.*, 1498 (1929).
[6] Challenger, F., Klein, L., and Walker, T. K., *J. Chem. Soc.*, 16 (1931).
[7] Wirth, J. C., and Nord, F. F., *Arch. Biochem.*, **1**, 143 (1942).
[8] Dickens, F., *Biochem. J.*, **32**, 1645 (1938).
[9] Goepfert, G. J., and Nord, F. F., *Arch. Biochem.*, **1**, 289 (1942).
[10] Kaushal, R., and Walker, T. K., *Nature*, **160**, 572 (1947).
[11] Fenton, H. J. H., and Jackson, H., *J. Chem. Soc.*, **75**, 3 (1899).

Functional Survival of Fowl Spermatozoa after Freezing at −79° C.

Shaffner, Henderson and Card reported that, in fowl semen to which lævulose had been added, about 30 per cent of the spermatozoa could be revived after freezing to −79° C.[1]. Some spermatozoa so treated apparently remained capable of fertilizing eggs, although the embryos died at a very early stage (10–15 hr.) of development[2].

Recent work at this Institute has shown that, if fowl semen is diluted to contain 15–20 per cent glycerol, it can be frozen to −79° C. and thawed at 40° C. without impairing the motility of the spermatozoa[3]. However, insemination into hens of semen containing more than 5 per cent glycerol, frozen or unfrozen, failed to result in fertile eggs. 2 per cent glycerol in the semen was the maximum concentration compatible with the retention of full fertilizing power. Nevertheless, there was some indication that the very few spermatozoa which survived freezing in this concentration of glycerol remained functional[4].

After insemination of normal semen, motile spermatozoa can be found at the top of the oviduct[5]; by contrast, after insemination of semen containing high concentrations of glycerol, no spermatozoa, live or dead, could be found there. Moreover, if the glycerol concentration of semen was reduced quickly *in vitro*, most of the spermatozoa were killed. It seemed likely, therefore, that the infertility of glycerol-treated semen was due to the spermatozoa being destroyed in the lower part of the hen's oviduct by the rapid removal of the glycerol.

At this point a hint was obtained from parallel experiments with red blood cells, from which glycerol can be removed by slow dialysis with very little damage to the cells[6]. Analogous experiments with fowl semen containing 15 or 20 per cent glycerol showed that dialysis against Ringer's solution removed the glycerol with very little reduction in the motility of the spermatozoa. Semen so treated was found to have unimpaired fertilizing capacity. On the basis of this result, experiments with frozen material were resumed.

Semen was diluted with equal volumes of 30 per cent glycerol in Ringer's solution, cooled rapidly to −79° C. and held at that temperature for ½–1 hr. After thawing at 40° C., it was dialysed in 'Cellophane' bags against Ringer's solution at 20° C. for 2 hr. About 50 per cent of the spermatozoa reviving after freezing were killed by this method of dialysis. When semen thus treated was inseminated, therefore, twice the usual amount was used, and 51 out of a total of 83 hens laid fertile eggs as a result. The capacity of spermatozoa treated in this way to survive in the oviduct seems little impaired, as fertility during the first week after insemination was 54 per cent. The fertility of eggs was assessed either by cracking them and examining the germinal disk[7], or by incubation. In incubated eggs the hatchability of fertile eggs was 71 per cent. 35 chicks have now been hatched from eggs fertilized with spermatozoa frozen at −79° C. for short periods (½–1 hr.), and all appear quite normal.

Work is at present being carried out on the effect on spermatozoa of longer periods of storage at low temperatures. In preliminary experiments, a smaller percentage of hens have laid fertile eggs after insemination with semen stored for more than 1 hr. at −79° C.; but some live chicks have been obtained from hens inseminated with semen so stored for thirty-three days. The possibility of an excessive amount of embryonic mortality under these conditions cannot yet be excluded.

It is clear that much more work will be required to determine optimal conditions and ultimate possibilities; but the present results demonstrate conclusively that storage of fowl spermatozoa at low temperatures is compatible with the retention of fertilizing capacity and the production of normal chicks.

C. Polge

National Institute for Medical Research,
Mill Hill,
London, N.W.7.
March 27.

[1] Shaffner, C. S., Henderson, E. W., and Card, C. G., *Poult. Sci.*, **20** 259 (1941).
[2] Shaffner, C. S., *Science*, **96**, 337 (1942).
[3] Polge, C., Smith, A. U., and Parkes, A. S., *Nature*, **164**, 666 (1949).
[4] Smith, A. U., and Polge, C., *Nature*, **166**, 668 (1950).
[5] van Drimmelen, G. C., *J. S. Afr. Vet. Med. Assoc.*, **16**, 97 (1945).
[6] Sloviter, H. A., *Lancet*, **1**, 823 (1951).
[7] Kosin, I. L., *Poult. Sci.*, **23**, 266 (1944).

Sickle-Cell Trait in Yemenite Jews

The large-scale immigration of Jews from all parts of the woeld to Israel provides an opportunity for the study of the physiological and pathological characteristics of the different ethnic groups. At present a survey of Mediterranean blood properties and a search for sickle-cell disease are being undertaken by us among these various groups.

A study of 105 children admitted consecutively to the Hadassah Children's Hospital at Rosh Ha'Ayin, all of whom are Yemenite Jews recently arrived, was undertaken as the first stage in this survey. The usual hæmatological methods were used. Sickling was searched for by use of the 'moist-stasis' method of Scriver and Waugh[1]. Among the 105 children examined, seven cases presenting the sickle-cell trait were found. In six of the seven cases it was possible to examine members of their families, and an additional five cases were detected, two of them adults, bringing the total of positives up to twelve.

The racial origin of the Yemenite Jews is equivocal. While they are considered by some to be aborigines of Yemen who adopted the Jewish religion long ago, they are usually regarded as descendants of a group of Jews which originated in the Eastern Mediterranean. In any event, they neither bear any resemblance to Negroes nor is heavy admixture of Negro blood at all probable for various reasons[2].

The high rate of positive instances encountered suggests that we may be dealing with a new source of the sickling gene, independent of the known reservoir of the sickling gene among Negroes.

This is apparently the first time that sickle cells have been found in any group of Jews, and no other reports of sickle-cell disease have come to our attention from this part of the world (that is, Israel and the Arab countries).

A more detailed report of our findings will appear elsewhere.

This investigation was supported by a grant from the Research Council of Israel. Our thanks are due to Dr. G. Mundel, director of the Hadassah Children's Hospital in Rosh Ha'Ayin, for permission to examine the children and for his interest.

F. Dreyfuss
M. Benyesch

Medical Department 'A',
Rothschild-Hadassah University Hospital,
and the
Hebrew University Hadassah Medical School,
Jerusalem.
March 6.

[1] Scriver, J. B., and Waugh, T. R., *Can. Med. Assoc. J.*, **33**, 375 (1935).
[2] Goitein, S. D. (personal communication).

Presence of Fœtal Hæmoglobin in Cooley's Anæmia

Cooley's anæmia[1] is a serious congenital disease often found among Mediterranean peoples and is associated with the appearance of red cells of uneven size and slightly distorted shape. The genetics of this disease are believed[2–4] to be similar to those of sickle-cell anæmia, a Cooley's trait being carried by heterozygotes, while homozygotes show the full anæmia, usually with fatal outcome before they reach adult age.

Hæmoglobin from a Cooley's anæmia patient aged about nine years was crystallized by the method of Drabkin[5]. The crystals resembled those of fœtal

hæmoglobin, described by Haurowitz[6], and by Jope and O'Brien[7].

Haurowitz[6] has shown that fœtal and adult hæmoglobins are denatured by alkali at different rates, and Jonxis[8,10] has used this property for identifying the two proteins as well as for determining their relative proportions in mixtures. Measurement of the alkaline denaturation-rate of the Cooley's anæmia hæmoglobin from two other patients aged about eight furnished strong evidence for the presence of fœtal hæmoglobin, which seemed to make up about half the total; there were indications that the other half consisted of adult hæmoglobin.

Jope and O'Brien[7] found the solubility of fœtal hæmoglobin in 2 *M* phosphate at 20° C. to be about 28 per cent higher than that of the normal oxy-hæmoglobin, while the solubilities of the two reduced hæmoglobins were practically identical. A comparison of the solubilities of Cooley's anæmia hæmoglobin in the oxygenated and reduced state with those of normal hæmoglobin at 20° C. gave qualitatively similar results.

Jope[11] discovered a difference between the ultra-violet absorption spectra of fœtal and adult hæmoglobin, the position of the tryptophane fine-structure band being at 2898 A. in the former while in the latter it lies at 2910 A. A measurement of the absorption spectrum of Cooley's anæmia hæmoglobin, kindly performed by Drs. E. R. Holiday and G. H. Beaven by the moving-plate method[12], showed the position of the fine-structure band in Cooley's anæmia hæmoglobin to be at 2902 A., thus furnishing evidence for the presence of a mixture of fœtal and adult hæmoglobin. An empirical relationship between the position of the tryptophane band and the fœtal-hæmoglobin content in artificial mixtures has been established by Beaven, Hoch and Holiday[13]. On the basis of their results the content of fœtal hæmoglobin in Cooley's anæmia was estimated as 40–60 per cent.

Evidence obtained by four independent methods thus suggests that a substantial proportion, probably about half, of the hæmoglobin of Cooley's anæmia patients more than eight years old consists of fœtal hæmoglobin. Since normally the fœtal form is completely replaced by the adult form before the age of six months, these results indicate that Cooley's anæmia may be associated with a congenital inability to complete the change-over from the fœtal to the adult mechanism of hæmoglobin synthesis.

Confirmation of the above results has been obtained from four further cases of the disease, of which Dr. L. Hamilton kindly sent me blood samples. The cases were children of Italian origin living in New York.

Details of this work will be published elsewhere.

A. M. Liquori

Istituto Chimico-Farmaceutico,
Università di Roma. March 15.

[1] Cooley, T. B., and Lee, P., *Trans. Amer. Ped. Soc.*, **37**, 20 (1925).
[2] Moncrieff, A., and Whitby, L. E. H., *Lancet*, ii, 648 (Sept. 22, 1934).
[3] Damashek, W., *Amer. J. Med. Sci.*, **205**, 643 (1943).
[4] Valentine, N. W., and Neel, J. V., *Arch. Int. Med.*, **74**, 185 (1944).
[5] Drabkin, D. L., *Arch. Biochem.*, **21**, 224 (1949).
[6] Haurowitz, F., *Hoppe-Seyl. Z.*, **125**, 232 (1935).
[7] Jope, H. M., and O'Brien, J. R. P., "Haemoglobin", 269 (London, 1949).
[8] Haurowitz, F., *Hoppe-Seyl. Z.*, **186**, 141 (1930).
[9] Jonxis, J. H. P., *Maanschr. Kindergeneskunde*, **5**, 363 (1936).
[10] Jonxis, J. H. P., "Haemoglobin", 261 (London, 1949).
[11] Jope, E. M., and O'Brien, J. R. P., "Haemoglobin", 205 (London, 1949).
[12] Holiday, E. R., *J. Sci. Instr.*, **14**, 166 (1937).
[13] Beaven, G. H., Hoch, H., and Holiday, E. R., *Biochem. J.* (in the press).

Relationship of Growth-Phase to the Reducing Activity of Bacterial Cells

In the course of an investigation[1] on the reduction of formaldehyde by a strain of *Pseudomonas æruginosa*, it was demonstrated that treatment of the bacteria with single amino-acids that were able to support adequately their growth in culture media, prior to the addition of formaldehyde, considerably enhanced the subsequent rate of uptake of the latter compound by the organism. This rise in reducing activity was assumed to be related to processes preparatory to cell multiplication. Pollock and Wainwright[2] found that the nitratase activity of washed suspensions of the coliform organism '1433' was markedly stimulated in the presence of tryptic meat broth or a mixture of eighteen amino-acids. They suggested that, in accordance with Spiegelman and Dunn's theory[3], the external supply of nitrogen would serve as a source for the synthesis of more enzyme protein.

To obtain further experimental evidence on these alternative hypotheses, a strain of *Escherichia coli* was selected for an investigation of its reducing power towards nitrate and methylene blue. The organisms were grown on nutrient agar for 18 hr. About 2×10^{10} bacteria, as determined by viable counts and turbidity measurements, were incubated with 50 per cent solutions of veal infusion broth with and without 0·5 mgm. of sodium nitrate for 1 hour. They were then centrifuged, washed and allowed to act on 0·5 mgm. of sodium nitrate in 2 ml. of distilled water aerobically for 1 hour and on 0·2 ml. of a 1 : 2,000 dilution of methylene blue in 4 ml. of distilled water in evacuated Thunberg tubes, respectively. All experiments were carried out at 37°. Sodium nitrite was determined with Griess Ilosvay reagent by comparing the intensity of the colour obtained with that of known standards, using the 550-mμ filter of a Leitz photo-electric colorimeter.

Table 1. Effect of Pretreatment of *E. coli* on Reducing Activity

Type of pretreatment	Amount of nitrite produced (mgm.)	Time of decolorization of methylene blue (min.)
None	0·037	18
Veal infusion broth	0·084	6
Veal infusion broth and sodium nitrate	0·166	5

Since pretreatment with veal infusion broth with and without sodium nitrate induced an increase in the yield of sodium nitrite, but more was produced when the nitrate was added to the broth, the explanation must be sought in a rise in cellular reducing power as well as specific enzyme activity.

Cultures of *E. coli* were grown for 3, 4 and 5 hr. The bacteria were added to sodium nitrate and methylene blue as described above.

Qualitative differences between young and old bacterial cells, such as in their susceptibility to certain antibiotics and viruses, have been known for some

Table 2. Relation of Age of *E. coli* Culture to Reducing Activity

Age of culture (hr.)	No. of bacteria	Amount of nitrite produced (mgm.)	Time of decolorization of methylene blue (min.)
3	10^{10}	0·143	6
4	10^{10}	0·104	8
5	10^{10}	0·094	11
18	2×10^{10}	0·037	18

time. The results presented in Tables 1 and 2 show a definite quantitative difference in the reducing ability of such cells, and seem to indicate dependence of the synthetic, energy-requiring processes of cellular reproduction on a high-reduction potential.

Paul H. Kopper
Department of Microbiology and Public Health,
Chicago Medical School,
Chicago 12, Illinois.
Feb. 1.

[1] Kopper, P. H., *J. Gen. Physiol.* (In the press).
[2] Pollock, M. R., and Walnwright, S. D., *Brit. J. Exp. Path.*, **29**, 223 (1948).
[3] Spiegelman, S., and Dunn, R., *J. Gen. Physiol.*, **31**, 153 (1947).

Some Host Relationships of the Potato-rot Nematode, *Ditylenchus destructor* Thorne, 1945

Thorne[1] described *Ditylenchus destructor* from potato (*Solanum tuberosum* L.) in Idaho, U.S.A., and recorded *Taraxacum officinale* Weber as a host. Baker[2] identified *D. destructor* from potato tubers in Prince Edward Island. Baker[4], working with a species of *Ditylenchus* infesting the roots of *Mentha arvensis* L. and conforming closely to Thorne's[1] description of *D. destructor*, transferred this nematode from *M. arvensis* to the potato tuber; typical potato-rot nematode injury was produced, thus confirming its identity as *D. destructor*. Baker[4] also made successful transfers of *D. destructor* from potato tubers and the roots of *M. arvensis* to the sweet potato and to onion bulbs (*Allium cepa* L.). He made successful return transfers from onion bulbs to potato tubers and to the sweet potato. Baker[4] and Thorne[5] have tentatively identified *D. destructor* from *Trifolium pratense* L. and *Solidago graminifolia* (L.) Salisb., the identification being subject to confirmation by transfer to potato tuber. Goodey and Goodey[6] recorded *Mentha arvensis* L. and *Sonchus arvensis* L. as hosts of *D. destructor* at Rothamsted.

In work in Prince Edward Island, successful transfers have been made from the roots of alsike (*Trifolium hybridum* L.) and red clover (*Trifolium pratense* L.) to the potato tuber, with the production of typical potato-rot nematode injury. Nematodes in a water suspension were inoculated into the tubers by the flap method[3], a hypodermic needle being used. Tubers from a potato plant grown in sterile soil, in which infested alsike roots were planted, exhibited typical potato-rot nematode injury. Transfers were also made of nematodes conforming to Thorne's[1] description of *D. destructor* from the roots of *Sonchus arvensis* to potato tubers; the lesions produced were small and the nematodes recovered were smaller than those originally taken from *S. arvensis*. Baker[4] attempted this transfer, but considered his results inconclusive. The possibility must therefore be considered that the nematode infesting the roots of *S. arvensis* is a variety of *D. destructor*, or even another species of *Ditylenchus*.

Larvæ, adults, and, in some cases, eggs, of nematodes resembling Thorne's[1] description of *D. destructor* have been found infesting the roots of a number of plants in Prince Edward Island, in addition to those mentioned above. The most frequent and most definitely infested of these are: *Solidago graminifolia* (L.) Salisb., *Linaria vulgaris* Hill, *Plantago major* L., *Taraxacum officinale* Weber, *Sisyrinchium angustifolium* Miller, *Vicia sativa* L. and *Daucus carota* L. The identity of the nematode from *D. carota* has been confirmed by Baker[4], who made a successful transfer to potato tubers. The nematodes were found within the healthy root tissues of all plants except *Taraxacum officinale*, in which they were beneath the dead epidermis usually adhering to the tap-roots. *D. destructor* has not so far been found infesting the aerial parts of any plants. Transfers to the potato tuber are still required to confirm the identity of the nematodes found in these plants.

This work is part of an investigation being conducted through the Potato-rot Nematode Research Committee, Science Service, under the direction of Dr. A. D. Baker.

V. E. Henderson
Division of Entomology,
Science Service,
Department of Agriculture,
Ottawa.
Jan. 9.

[1] Thorne, G., *Proc. Helminth. Soc. Washington*, **12**, 27 (1945).
[2] Baker, A. D., *Sci. Agric.*, **26**, 139 (1946).
[3] Baker, A. D., 78th Ann. Rep. Ent. Soc. Ont., 1947, 32 (1948).
[4] Baker, A. D. (unpublished manuscripts, 1947).
[5] Thorne, G. (personal communication, 1950).
[6] Goodey, T., and Goodey, J. B., *J. Helminth.*, **23**, 89 (1949).

An Indigenous Source of Swollen Shoot Disease of Cacao

Cola chlamydantha K. Schum. is already known to be a natural host of cacao viruses in the Wiawso district, Western Province, Gold Coast[1]. It is now further evident that cacao virus infection occurs in this species in other parts of the Western Province, though apparently to a less extent than in the north-west, around Wiawso.

C. chlamydantha is a small understorey tree native to the Guinea Forest, reputedly restricted to parts of Liberia, the Ivory Coast, the Western Province of the Gold Coast, southern Nigeria and the French Cameroons. It is absent from the forests of Ashanti and the Eastern Province of the Gold Coast and apparently from most of southern Nigeria.

Surveys for virus infection in the species have been confined to the Gold Coast. Survey stations were selected arbitrarily at 1- to 2-mile intervals along stretches of road, and at each one a footpath was followed for 100–200 yards. All conveniently placed specimens were examined for symptoms, and where necessary stem tips were collected for virus transmission tests in the laboratory, using cacao as the indicator and *Pseudococcus njalensis* Laing as the vector.

From Wiawso, *C. chlamydantha* was traced eastwards and north-westwards as far as it occurred. Specimens were common at twenty-five out of twenty-nine stations along a 40-mile transect of the area, and symptoms were seen at fifteen of these stations. At the latter, most of the specimens examined were symptomless; but it need not follow that all such were virus-free. Laboratory tests with material from symptomless specimens chosen at random along forest paths near Wiawso showed that twelve out of twenty-seven trees, one out of four coppiced trees and three out of nineteen saplings were infected.

Another survey was conducted along stretches of road in the Dunkwa, Enchi, Prestea, Axim, Sekondi and Cape Coast districts of the Western Province.

Virus transmission was obtained from five out of seventy-five specimens, only one of which had shown definite symptoms. The infected specimens were from three stations, respectively near Achichere in the centre and Dompim and Aiyim in the extreme south of the Province. Cacao is not extensively grown in these localities, and at none of them is swollen shoot disease of cacao known. No infection of *C. chlamydantha* was found at the other twenty-nine survey stations.

From these and the previous results[1], it seems that cacao virus infection is endemic in *C. chlamydantha* around Wiawso. Since a cursory survey in other parts of the Western Province revealed infected trees at about a tenth of the localities visited, it may be assumed that infection is widespread in *C. chlamydantha* throughout its Gold Coast range. The high incidence of infection around Wiawso, and elsewhere, and the occurrence of infected specimens where swollen shoot of cacao is unknown, strongly suggest that virus infection of *C. chlamydantha* antedates that of cacao.

Taking into account the close ecological association of *C. chlamydantha* and cacao which results from farming practice and the exceptional ease with which virus can be transmitted from one to the other, it is postulated that *C. chlamydantha* is the immediate natural reservoir of cacao viruses in the Western Province. Its control is a matter of prime urgency.

I am indebted to A. Attafuah and N. K. Lovi for assistance given in this work.

J. McA. Todd

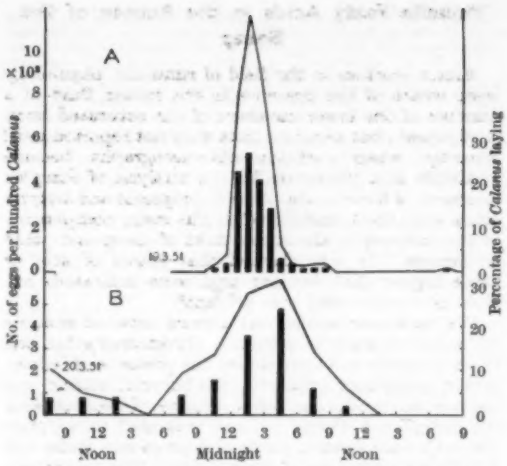
West African Cacao Research Institute,
Tafo, Gold Coast.
April 16.

[1] Posnette, A. F., Robertson, N. F., and Todd, J. McA., *Ann. App. Biol.*, **37**, 229 (1950).

Time of Egg-laying in the Planktonic Copepod *Calanus*

In the course of some observations on the cytology of *Calanus* made in Plymouth in June 1950, the eggs in the oviduct of a fairly high proportion of females examined were found to have reached full metaphase of the first reduction division (this is the stage reached when the eggs are laid). On the other hand, in March 1951 at Millport it was difficult to find eggs in the oviduct of *Calanus* in which the chromosomes had reached further than the pachytene stage. This was in spite of the fact that a high proportion of the females brought into the laboratory at this date laid a batch of eggs overnight. It seemed as if few of these *Calanus* would be ready to lay before night. In order to find at what time the actual spawning takes place at Millport, 104 ripe female *Calanus* were put singly into small glass dishes containing about 20 ml. of filtered sea water and examined hourly. The *Calanus* were caught between 50 and 100 metres at 4 p.m. and examination was begun at about 6 p.m. The results are shown in diagram *A*; 68 per cent spawned between midnight and 3 a.m. and the bulk of the rest by 4 a.m. Only five of the 104 did not lay. The average number of eggs was very constant at about forty per female. There was no difficulty in finding primary oocysts with full metaphase plates in females fixed at 2 a.m.

It seemed possible that this rather surprising result might have been caused by the shock of capture



The continuous line represents the number of eggs laid per hour (*A*) or in 3 hr. (*B*). The vertical columns represent the percentage of *Calanus* laying

and examination, or by the sudden reduction of pressure, acting after an interval of about eight hours. A second tow-netting was therefore taken early the following morning (4 a.m.), and fifty ripe females were set up as before but examined only every three hours. Diagram *B* shows that laying was still concentrated in the early hours of the morning. The peak is not so marked, possibly because of the longer period of starvation. It has been found that the number of eggs laid by *Calanus* is closely dependent on the amount of food available.

It is known that egg-laying in some Crustacea takes place during the night[1,2]. Dr. C. M. Yonge has told us that he found the same with the shore crab *Carcinus mœnas*.

The eggs of *Calanus* are heavier than sea water and sink about 36 m. in 24 hr.[3], which is about the minimum time it takes for the eggs to hatch. The young stages of *Calanus* are found continuously in the upper layers, and nauplii almost entirely above 30 m.[4,5]. It is therefore advantageous for the nauplius that the egg should be laid as near the surface as possible. Nicholls has also shown that female *Calanus* in January show marked diurnal vertical migration. The bulk of the females are, however, at the surface before midnight, and by 3 a.m. the descent is well under way.

It will be interesting to find whether the *Calanus* which are found at the surface both day and night in May and June show the same behaviour in egg-laying.

J. P. Harding

British Museum (Natural History),
London, S.W.7.

S. M. Marshall
A. P. Orr

Marine Station,
Millport.
April 22.

[1] Nair, K. B., *Proc. Ind. Acad. Sci.*, B, **9**, 175 (1939).
[2] Nair, K. B., *Proc. Ind. Acad. Sci.*, B, **14**, 543 (1941).
[3] Gross, F., and Raymont, J. E. G., *Proc. Roy. Soc. Edin.*, B, **61**, 288 (1942).
[4] Nicholls, A. G., *J. Mar. Biol. Assoc.*, **19**, 139 (1933).
[5] Nicholls, A. G., *J. Mar. Biol. Assoc.*, **19**, 83 (1933).

Volatile Fatty Acids in the Rumen of the Sheep

Early workers in the field of ruminant physiology were aware of the presence in the rumen fluid of a number of the lower members of the saturated fatty acid series[1]; but accurate data were not reported until recently, when partition chromatography became available as a procedure for the analysis of complex mixtures of these acids. Acetic, propionic and butyric acids were then established as the main components of the mixture in the rumen fluid of sheep and other ruminants. It was claimed that traces of acid or acids higher than butyric acid were indicated, but that no formic acid was present[2].

We have now carried out a more detailed analysis by a combination of partition chromatographic and other methods and have shown the presence of formic, acetic, propionic, *n*-butyric, *iso*-butyric, valeric and caproic acids, and probably a trace of heptoic acid. An unbuffered 'Celite' column was used to separate the acids into formic, acetic and propionic acids, and a fraction containing higher acids. The latter was transferred to a buffered column to be separated into three parts, the first containing *n*-butyric and *iso*-butyric acids, the second valeric acid and the third caproic and higher acids. The third fraction was transferred again to a buffered column suitable for the separation of caproic and heptoic acids. Formic acid and *iso*-butyric were identified and estimated by separate methods. The valeric acid was in one instance separated into two fractions, the larger of which was identified as *n*-valeric acid by its *R*-value; the smaller fraction was probably one of its isomers, but this was not finally identified. The 'caproic' fraction contained a very small amount of acid corresponding approximately in *R*-value to heptoic acid.

A typical analysis of the acids in the rumen fluid of a sheep fed on wheat hay is:

Formic acid	1·0 per cent	*iso*-Butyric acid	0·7 per cent
Acetic acid	68·0 ,,	Valeric acid	2·6 ,,
Propionic acid	18·0 ,,	Caproic acid	0·7 ,,
n-Butyric acid	9·0 ,,	Heptoic acid (?)	trace

The substrates from which the fatty acids originate in the rumen and the intermediate steps leading to their formation have as yet received little attention. The production of acetic and propionic acids from pure cellulose was demonstrated *in vitro* by Elsden[3] and Marston[4], and the formation of acids by two organisms isolated from the rumen was studied in detail by Sijpestein[5]. One of these organisms produced propionic and acetic acids, and the other succinic and acetic. Decarboxylation of succinic to propionic acid was later shown to occur in the rumen[5,6].

It is reasonable to suppose that the dissimilation of other polysaccharides and of proteins may account for a considerable part of the three main acids produced in the rumen; and since *iso*-butyric and the isomers of valeric acid are known to occur as products of the amino-acid metabolism of a number of anaerobes of the *Clostridium* genus[7], these acids also may be derived from the protein fraction of the fodder.

We have made a preliminary investigation of the origins of some of the higher acids by including acetic and propionic acids labelled with carbon-14 in the rumen fermentation. Wheat hay was fermented *in vitro* as described by Gray and Pilgrim[8]; labelled acetic acid ($CH_3{}^{14}COOH$) or propionic acid ($CH_2CH_3{}^{14}COOH$) was added to the inoculum, and the distribution of the carbon-14 among the fatty acids was determined at the end of the 48-hr. fermentation period. The results indicated that acetic acid contributed to the formation of a large part of the butyric acid produced, since the specific (molar) activity of this acid was about the same as the mean molar activity of the acetic acid; it contributed also to the formation of the valeric acid and to the caproic acid (which in these analyses was not separated from the trace of higher acid). Propionic acid was shown to contribute to the formation of valeric acid and, to a slight extent, to the formation of the caproic acid fraction (caproic and higher acid). The mechanism of formation of these higher normal acids may well involve the addition of a 2 carbon compound to acetic, propionic or butyric acid as demonstrated by Barker and his colleagues[9,10] in the synthesis of volatile fatty acids by *Clostridium kluyveri*. Acetic acid also contributed to the formation of a small but significant proportion of the propionic acid produced in the fermentation.

F. V. Gray
A. F. Pilgrim
H. J. Rodda
R. A. Weller

Division of Biochemistry and General Nutrition,
Commonwealth Scientific and Industrial
Research Organization,
Adelaide.
Jan. 30.

[1] Mangold, E., *Nut. Abst. and Rev.*, **3**, 647 (1934).
[2] Elsden, S. R., *J. Exp. Biol.*, **22**, 51 (1945).
[3] Marston, H. R., *Biochem. J.*, **42**, 564 (1948).
[4] Sijpestein, A. K., Thesis (University of Leyden, 1948).
[5] Elsden, S. R., and Sijpestein, A. K., *J. Gen. Microbiol.*, **4**, x (1950).
[6] Johns, A. T., *Nature*, **164**, 620 (1950).
[7] Cohen-Bazire, G., Cohen, G. N., and Prevot, A. R., Ann. Inst. Pasteur, **77**, 471 (1949).
[8] Gray, F. V., and Pilgrim, A. F., *J. Exp. Biol.* (in the press).
[9] Bornstein, B. T., and Barker, H. A., *J. Biol. Chem.*, **172**, 659 (1948).
[10] Stadtman, E. R., Stadtman, T. C., and Barker, H. A., *J. Biol. Chem.*, **178**, 677 (1949).

Length of the Period of the Periodic System

If each period in the periodic system ends in a rare gas (H,He 1st period, Li—Ne 2nd, etc.), then the number of elements in a period can be found from the ordinal number of the period by the following formula:

$$L = \frac{(2n + 3 + (-1)^n)^2}{8},$$

where n is the number of the period and L is the number of elements in the period.

This formula also gives the relation between the number (n) of electron shells in an atom, and the number (L) of the elements in the period in which the particular atom is placed.

M. V. Tomkeieff

88 Moorside North,
Newcastle upon Tyne 4.
Feb. 3.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Saturday, June 9

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS (at Neville Hall, Newcastle-upon-Tyne), at 2.30 p.m.—Mr. W. B. Bell and Mr. E. L. J. Potts: "The Development of the 'Duneim' Circular Fluorescent Mine Lighting Unit".

Tuesday, June 12

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. R. P. Lynton: "Some Thoughts on Research Method".

INCORPORATED PLANT ENGINEERS, EAST LANCASHIRE BRANCH (at the Engineers' Club, Albert Square, Manchester), at 7.15 p.m.—A Representative of Cambridge Instruments, Ltd.: "Maintenance of Industrial Instruments".

Wednesday, June 13

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. G. G. Simpson (American Museum of Natural History): "Origin and Early Evolution of the Primates".*

Thursday, June 14

CHADWICK PUBLIC LECTURE (at the Chelsea Physic Garden, Swan Walk, London, S.W.3), at 4 p.m.—Prof. T. A. Bennet-Clark, F.R.S.: "The Capacity of Vegetation to Support Human Population".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Cyril Hinshelwood, F.R.S.: "Some Researches on the Physical Chemistry of Bacterial Cells".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. D. G. Northcott: "Modern Algebra and the Foundations of Geometry".

Friday, June 15

UNIVERSITY OF LONDON (at Guy's Hospital Medical School, London Bridge, London, S.E.1), at 5 p.m.—Prof. E. K. Rideal, F.R.S.: "Matter in the Boundary State" (Fison Memorial Lecture).* (Admission by ticket only, obtainable from the Dean.)

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Prof. R. Dohrn: "The Naples Zoological Station and its Work".*

Saturday, June 16

BIOCHEMICAL SOCIETY (in the Department of Physiology, The Medical School, Hospitals Centre, Birmingham), at 1.45 p.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN MATHEMATICS—The Clerk, Birkbeck College, Breams Buildings, London, E.C.4 (June 15).

ASSISTANT LECTURERS IN ORGANIC CHEMISTRY—The Principal, Royal Holloway College, Englefield Green, Surrey (June 15).

HENRY GEORGE PLIMMER FELLOWSHIP for research which may include morbid anatomy, histological anatomy, chemical pathology, protozoology, bacteriology and allied subjects in either zoology, medicine or botany—The Registrar, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7 (June 15).

JUNIOR LECTURER IN PHARMACOLOGY—The Dean, Guy's Hospital Medical School, London, S.E.1 (June 15).

ASSISTANT LECTURER IN PHYSICS, for Intermediate and Final B.Sc. courses—The Principal, Guildford County Technical College, Stoke Park, Guildford, Surrey (June 16).

LECTURER IN CHEMISTRY at the Technical College of Monmouthshire, Crumlin—The Director of Education, County Hall, Newport, Mon. (June 16).

LECTURER IN THE DEPARTMENT OF PHARMACY—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (June 16).

MECHANICAL AND ELECTRICAL ENGINEERS in the Air Ministry Works Department, in connexion with the design, operation and maintenance of ground mechanical and electrical works services on R.A.F. stations at home and overseas and on Civil Aviation stations—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.19/48A or D.370/50A (June 16).

SENIOR EXPERIMENTAL OFFICERS, EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICERS at Admiralty Experimental Establishments in the vicinity of London, Baldock, Greenock, Haslemere, Portsmouth, Rosyth and Weymouth: (Ref. C.632/50A) MECHANICAL ENGINEERS with research and development experience in light mechanisms, (Ref. D.368/50A) ELECTRICAL ENGINEERS with experience in telecommunications, radar, electronics or light electrical mechanisms, (Ref. A.335/50A) PHYSICISTS interested in general physical problems, electronics or acoustics—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (June 16).

SENIOR LECTURER to be responsible for teaching ADVANCED PHYSICAL METALLURGY to honours B.Sc. (metallurgy) standard, a LECTURER to be responsible for teaching FERROUS METALLURGY (mainly production) to honours B.Sc. (metallurgy), and to H.N.C. in metallurgy standard, and a LECTURER to be responsible for teaching NON-FERROUS METALLURGY to honours B.Sc. (metallurgy) and to H.N.C. in metallurgy standard—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (June 16).

SENIOR LECTURER IN MATHEMATICS, a LECTURER IN PHYSICS, and a RESEARCH ASSISTANT IN PHYSICS to work in the field of ultra-high frequency electronics—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (June 16).

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS at Admiralty Experimental Establishments in the vicinity of London, Baldock, Greenock, Haslemere, Portsmouth, Rosyth and Weymouth: (Ref. A. 336/50A) PHYSICISTS capable of undertaking research or development in general physical problems, electronics, acoustics or thermodynamics, (Ref. D.367/50A) ELECTRICAL ENGINEERS qualified to undertake research, development or design in telecommunications, radar, electronics, instrumentation or light electrical mechanisms, (Ref. C.631/50A) MECHANICAL ENGINEERS capable of design, development or research work in light mechanisms, structures or hydrodynamics—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (June 16).

BIOCHEMIST, SOIL CHEMISTS, and a SOIL PHYSICIST, in the Soil Bureau of the Department of Scientific and Industrial Research, Wellington—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (June 18).

LIGHT ELECTRICAL ENGINEERS and PHYSICISTS (Principal Scientific Officer grade) at the Royal Aircraft Establishment, Farnborough, to lead a research and development team concerned with the use of magnetic and electronic amplifiers in aircraft equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.156/51A (June 18).

PRINCIPAL SCIENTIFIC OFFICER IN THE DEPARTMENT OF SUPPLY AERONAUTICAL RESEARCH LABORATORIES, Fishermen's Bend, Vic., to be responsible as Section Head directly under the Superintendent of the Division for the initiation and conduct of researches in the theory of aircraft structures, and a SENIOR SCIENTIFIC OFFICER to assist the Section Head in and conduct researches in the theory of aircraft structures—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (June 18).

PRINCIPAL SCIENTIFIC OFFICER IN THE DEPARTMENT OF SUPPLY RESEARCH AND DEVELOPMENT BRANCH, Salisbury, South Australia, to be responsible, under the Superintending Scientist, Propulsion Research Laboratory, for the organization and direction of a Propulsion Engineering Group engaged on the development of rocket motors—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (June 18).

RESEARCH LECTURER IN COLOUR CHEMISTRY AND DYEING—The Registrar, The University, Leeds 2 (June 20).

APPLIED MATHEMATICIANS, PHYSICISTS or MECHANICAL or AERONAUTICAL ENGINEERS (Senior Scientific Officer or Scientific Officer grade) at a Ministry of Supply Experimental Aircraft Establishment in southern England, for research investigations and flight testing techniques of helicopters—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.157/51A (June 22).

ASSISTANT IN CHEMISTRY, and an ASSISTANT IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (June 22).

LECTURER IN GEOGRAPHY (with special qualifications in geomorphology)—The Registrars, The University, Manchester 13 (June 22).

SENIOR SCIENTIFIC OFFICERS or SCIENTIFIC OFFICERS for microwave valve development and experimental production at an Admiralty establishment in Essex—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.307/51A (June 22).

ASSISTANT LECTURER IN THE DEPARTMENT OF INORGANIC AND PHYSICAL CHEMISTRY—The Registrar, The University, Liverpool (June 23).

CHAIR OF APPLIED MATHEMATICS—The Registrar, University College of Wales, Aberystwyth (June 23).

DEMONSTRATOR IN CHEMISTRY AND PHYSICS—The Registrar, Wye College, Ashford, Kent (June 23).

LECTURER IN BIOCHEMISTRY—The Registrar, University College of Wales, Aberystwyth (June 23).

SENIOR ASSISTANT PHYSICIST for duties mainly in the Radiotherapy Department—The Clerk to the Governors, St. Thomas's Hospital, London, S.E.1 (June 23).

TUTORIAL STUDENTSHIPS IN ORGANIC CHEMISTRY, PHYSICAL CHEMISTRY, CHEMICAL ENGINEERING, CIVIL ENGINEERING, MECHANICAL ENGINEERING, ELECTRICAL ENGINEERING, PHYSICS and PHARMACOLOGY—The Registrar, King's College, Strand, London, W.C.2 (June 23).

DEMONSTRATOR IN THE DEPARTMENT OF AIRCRAFT PROPULSION—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks, endorsed 'Demonstrator, Aircraft Propulsion' (June 25).

CHEMIST (Principal Scientific Officer or Senior Scientific Officer grade) at the Ministry of Supply headquarters in London—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4030/51 (June 28).

LECTURER or ASSISTANT LECTURER IN VETERINARY PARASITOLOGY, and an ASSISTANT LECTURER IN VETERINARY PATHOLOGY—The Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1 (June 29).

ASSISTANT LECTURER IN VETERINARY BACTERIOLOGY—The Registrar, The University, Liverpool (June 30).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY AND CHEMISTRY—The Dean, Guy's Hospital Medical School, London Bridge, London, S.E.1 (June 30).

ASSISTANT PROFESSOR OF HISTOLOGY AND EMBRYOLOGY at Dalhousie University, Halifax, Nova Scotia—Prof. R. L. Saunders, c/o Anatomy Department, The University, Edinburgh (June 30).

BETTY BROOKES' RESEARCH FELLOW (to devote himself to a study of brain metabolism in relation to nervous and mental disease)—The Whitley Professor of Biochemistry, University Museum, Oxford (June 30).

CHEMIST IN THE SECTION OF INSECTICIDES AND FUNGICIDES at Long Ashton Research Station—The Registrar and Secretary, The University, Bristol (June 30).

GRADUATE CHEMISTS (with biochemical training and interests) to assist in a research programme on nucleic acids and nucleoproteins at the Chester Beatty Research Institute—The Secretary and House Governor, Royal Cancer Hospital, Fulham Road, London, S.W.3 (June 30).

RESEARCH CHEMIST IN THE DEPARTMENT OF FISHERIES, CEYLON—The High Commissioner for Ceylon in the United Kingdom, 13 Hyde Park Gardens, London, W.2 (June 30).

RESEARCH OFFICER (organic chemist) IN THE DIVISION OF FOOD PRESERVATION AND TRANSPORT, Homebush, N.S.W.—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3389 (June 30).

RESEARCH SCHOLARSHIP (candidates must have a good honours degree in chemistry)—The Registrar, The University, Reading (June 30).

SENIOR PLANT PATHOLOGIST, and a SENIOR PLANT BREEDER—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (June 30).

ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Leeds 2 (July 2).

RESEARCH DEMONSTRATORS (2) IN PHYSICS—The Registrar, University College, Cathays Park, Cardiff (July 14).

CHAIR OF ICELANDIC LANGUAGE AND LITERATURE in the University of Manitoba, Winnipeg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 15).

DEMONSTRATORS IN THE BIOLOGY DEPARTMENT—The Registrar, University College of North Staffordshire, Keele, Staffs, endorsed 'Biology Demonstrator' (July 15).

PROFESSOR OF PHYSIOLOGY, and a SENIOR LECTURER IN PHYSIOLOGY, at the University of Otago Medical School, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 15).

SENIOR LECTURER or LECTURER IN BACTERIOLOGY at the University of Otago Medical School, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 15).

FORESTRY OFFICERS IN THE DIVISION OF AGRICULTURE AND LANDS, Southern Rhodesia—The Secretary to the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (July 17).

LECTURER IN THE DEPARTMENT OF GEOLOGY AND MINERALOGY, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

LECTURER IN MEDICAL ENTOMOLOGY—The Secretary, Department of Entomology and Parasitology, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool 3 (July 31).

LECTURER IN ZOOLOGY at the University of Natal, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

ASSISTANT EXPERIMENTAL OFFICERS in various Government departments and divided between the following main groups and subjects: (*a*) mathematical and physical sciences, (*b*) chemistry and metallurgy, (*c*) engineering subjects, and (*d*) miscellaneous (including, for example, geology, library and technical information services)—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3068 (October 1).

LECTURER IN LAND SURVEYING at the University of Natal, Durban, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 31).

ASSISTANT CIVIL ENGINEER for general civil engineering duties in the Public Works Department, Fiji—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/206.

ASSISTANT ENGINEER (with some experience of railway engineering including bridge work and general reinforced concrete construction) to the Nigerian Railways, to take charge of Engineering Sections—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27333/6.

ASSISTANT IN CHEMISTRY—The Principal, Royal Technical College, Salford 5.

ASSISTANT LECTURER IN THE DEPARTMENT OF CHEMISTRY, COLOUR CHEMISTRY AND DYEING, an ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS, and a TEACHER OF MATHEMATICS—The Principal, Technical College, Queen Street South, Huddersfield.

ASSISTANT LECTURER IN PLANT PATHOLOGY in the School of Agriculture—The Registrar, The University, Nottingham.

BROADCASTING ENGINEERS in the Broadcasting Department, Gold Coast—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27326/44.

CHEMIST OF ENGINEER I IN THE PRODUCTION PLANNING SECTION, at Risley headquarters—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

CHIEF ENGINEER to the Electricity Corporation of Nigeria—E. C. Inston, Electricity Corporation of Nigeria, The Corner House, Great Peter Street, London, S.W.1.

DEMONSTRATOR for the subjects of ELECTRONICS and ELECTRICAL ENGINEERING up to A.2 H.N.C. standard and to assist with the teaching of elementary mathematics and science—The Principal, School of Electronics, Malvern, Worcs.

DEMONSTRATOR IN BOTANY (with particular reference to Mycology)—The Registrar, The University, Nottingham.

ENGINEER (with an honours engineering degree, corporate membership of the I.M.E. or I.E.E., or equivalent qualifications) to undertake development work in connexion with metallurgical engineering processes (Ref. ARB/6), and TECHNICAL ASSISTANTS (with honours metallurgical or engineering degree or equivalent qualifications) to undertake development work on processes including machining, press work, metal fabrication and various aspects of welding and jointing (Ref. ARB/7), at Springfields Factory, Salwick, Preston—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting the appropriate Ref. No.

EXECUTIVE ENGINEER IN THE PUBLIC WORKS DEPARTMENT, Nigeria—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/4.

EXECUTIVE ENGINEER for general civil engineering duties in the Public Works Department, Northern Rhodesia—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/115.

GRADUATE PHYSICISTS, PHYSICAL CHEMISTS and ENGINEERS, for fundamental scientific research problems associated with gas utilization or production problems in the gas industry—The Gas Research Board (REC. 5014–6), The Abbey, Southend Road, Beckenham, Kent.

HEAD OF THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING—The Principal, Technical College, Queen Street South, Huddersfield.

JUNIOR GEOLOGIST (with qualifications and practical experience in mining geology) by the Government of Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.27533.E.

LECTURER IN THE DEPARTMENT OF ELECTRICAL AND RADIO ENGINEERING—The Registrar, Municipal College, Portsmouth.

LECTURER IN PHYSICS—The Registrar, The University, Nottingham.

METEOROLOGICAL OFFICERS (women, with honours degree in mathematics, physics or geography) for Special Short-Service Commissions—The Director, Women's Royal Naval Service, Admiralty, London, S.W.1.

RESIDENT CONSTRUCTION ENGINEER to supervise the erection, installation and testing in Malta of a complete steam power plant comprising 3 × 5,000 kW. sets and 3 × 70,000 lb. oil-fired boilers and associated equipment—Messrs. Preece, Cardew and Rider, 8–10 Queen Anne's Gate, London, S.W.1.

SENIOR LECTURER IN THE METHODS OF TEACHING GEOGRAPHY—The Secretary, University of London Institute of Education, Malet Street, London, W.C.1.

SUPERVISING ENGINEER IN THE PUBLIC WORKS DEPARTMENT, British Guiana—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/161.

SURVEYORS to carry out triangulation, topographical and cadastral surveying in Tanganyika—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27076/21/51.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences, No. 863, Vol. 243: A Study of a High-Current Toroidal Ring Discharge. By Dr. A. A. Ware. Pp. 197–220. (London: Cambridge University Press, 1951.) 8*s*. [94

Aluminium Development Association. Information Bulletin No. 1: An Introduction to Aluminium and its Alloys. Pp. 50. (London: Aluminium Development Association, 1951.) [94

Transactions of the Royal Society of Edinburgh. Vol. 62, Part 1, No. 3: On the Cranial Structure of an Early Paleoniscid, *Kentuckia*, gen. nov. By Dr. Dorothy H. Rayner. Pp. 53–83. (Edinburgh and London: Oliver and Boyd, Ltd., 1951.) 8*s*. [94

Electric Eyes: a Concise and Elementary Description of the Photoelectric Cell, for the Non-technical Reader; its Uses in Industry, and its Uses and Shortcomings in Colorimetry. By A. J. Fawcett. Pp. 28. (Salisbury: The Tintometer, Ltd., 1951.) 1*s*. 6*d*. [94

Liverpool Observatory and Tidal Institute. Annual Report, 1950. Pp. 16. (Liverpool: Observatory and Tidal Institute, 1951.) [94

Home Office. Fumigation with Ethylene Oxide: Precautionary Measures. Pp. 12. (London: H.M. Stationery Office, 1951.) 6*d*. net. [94

Management of the Smaller Office. Pp. 92. (London: British Institute of Management and Office Management Association, 1951.) 6*s*. 3*d*. [94

British Standard 844: 1951, Sampling and Testing Vegetable Adhesives. Pp. 16. (London: British Standards Institution, 1951.) 2*s*. net. [94

Other Countries

Report and Accounts of the National Botanic Gardens of South Africa for the Year ending 31st December 1950. Pp. 20. (Newlands, C.P.: National Botanic Gardens, 1951.) [94

Commonwealth of Australia: Commonwealth Scientific and Industrial Research Organization. Second Annual Report for the Year ending 30th June 1950. Pp. vi+320. (Melbourne: Government Printer, 1951.) [94

Department of Agriculture, Jamaica. Bulletin No. 46: Banana Leaf Spot Disease Control in Jamaica. Compiled by E. B. Martyn and A. McIlwain. Pp. 30+16 plates. (Kingston: Government Printer, 1950.) 1*s*. [94

Visindafélag Islendinga (Societas Scientiarum Islandica). The Eruption of Hekla, 1947–1948. II, 1: The Approach and Beginning of the Hekla Eruption; Eyewitness Accounts, by Sigurour Pórarinsson; II, 2: A Study of the Earliest Photographs of the Eruption, by Trausti Einarsson. Pp. 24+16+14 plates. 12*s*. IV, 2: Rate of Production of Material during the Eruption, by Trausti Einarsson; IV, 3: The Flowing Lava; Studies of its Main Physical and Chemical Properties, by Trausti Einarsson. Pp. 18+70+8 plates. 12*s*. IV, 4: Chemical Analyses and Differentiation of Hekla Magma, by Trausti Einarsson; The Basic Mechanism of Volcanic Eruptions and the Ultimate Causes of Volcanism, by Trausti Einarsson. Pp. 34+30. 10*s*. (Reykjavík: H. F. Leiftur, n.d.) [94

Smithsonian Institution: Institute of Social Anthropology. Publication No. 11: Quirogs, a Mexican Municipio. By Donald D. Brand assisted by José Corona Núnez. Pp. v+242+35 plates. (Washington, D.C.: Government Printing Office, 1951.) 1.75 dollars. [94

GRADUATES IN CHEMISTRY AND Chemical Engineering. A food manufacturing company in the Greater London area, marketing its well-known products on a large scale, is able, by reason of planned expansion, to offer opportunities for Science Graduates to train for executive appointments within its production division. Candidates will be given an intensive and well planned course of training (6-9 months' duration) to equip them for management responsibilities, which they will assume immediately on completion of the course. The company look for qualities of leadership, decision and readiness to shoulder responsibilities and can offer opportunities of promotion to higher management posts to men of the right calibre. The appointments carry salaries well above the average, together with non-contributory pension, life assurance and sickness benefits. Graduates (22-28 years) who are determined on a career which allows scope for initiative within an organization which recognizes individual merit are invited to write, in confidence, sending full details of education and career to date, to Box 578, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

SAFETY AND TRAINING OFFICER. A food manufacturing company of high national repute invites applications for an executive appointment as Safety and Training Officer at its factory in the Home Counties. The position requires a man who has had wide factory experience and is fully capable of (a) effecting complete safety measures within the company's work, and (b) training unskilled and semi-skilled operatives in standardized production techniques. Age limits 30-40 years. This is an important appointment carrying a salary well above the average, plus non-contributory pension, life assurance and sickness benefits.—Applications, which will be treated in confidence, should give full details of age, education and experience, should be sent to Box 579, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

EXPERIENCED PHYSICIST, AGED 29-34, required for research work connected with the fundamental physical properties of vegetable fibres. Experience in this particular field is not important, but a sound knowledge of basic physics and ability to prosecute original work essential. Some interest in botany or microscopy would be an advantage. The post carries F.S.S.U. benefits. —Further details and conditions of appointment on application to the Secretary, the British Jute Trade Research Association, Kinnoull Road, Kingsway West, Dundee.

ELECTRONIC TUBE DEVELOPMENT AND manufacture. Engineers and Physicists required for progressive technical and supervisory positions in our development and manufacturing departments. Successful applicants will have exceptional opportunities for advancement in the rapidly expanding electronics industry. Qualifications: Good degree in engineering or physics. Previous experience desired but not essential. Applicants graduating this year and free of National Service obligations will receive special consideration and, after appointment, will be given comprehensive training. Salary according to age and experience, but will not be less than £425 per annum for honours graduates at age 21.—Application should be made to Personnel Officer, Mullard Radio Valve Co., Ltd., New Road, Mitcham Junction, Surrey.

DUNLOP RUBBER CO., LTD., BIRMINGham, require a Technical Assistant, preferably graduate in engineering or chemistry, for the Patent Department. Some patent experience desirable but not essential. Application should include full details of academic and technical training and industrial experience, if any. Salary according to qualifications.—Apply to Personnel Manager, Fort Dunlop, Erdington, Birmingham.

APPOINTMENTS WANTED

PHYSICAL CHEMIST/CHEMICAL ENGINeer, Ph.D., B.Sc., A.R.I.C., six years' industrial and academic research experience. Available autumn to consider Senior Research post of responsibility. Work envisaged must be up to publication standard. Indicate salary range. Only posts carrying commensurate salary will be considered.—Box 560, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

AGRONOMIST, COLONIAL AGRICULtural Service (Medallist), wide experience, 24 years' tropical production and markets, six years' agro-horticultural studies in Midlands; soils, propagation, pests, pathology, feeding-stuffs; with chemical analysis and official publications, seeks responsible advisory or representative appointment.—Box 558, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

GRANTS & SCHOLARSHIPS

FELLOWSHIPS FOR WOMEN GRADUATES, 1952–53

The British Federation of University Women announce: (a) City of London International Residential Scholarship, at Crosby Hall, London, £300, for research or other postgraduate work. John Stone and Florence Stoney Studentship, £500, for research in biological, geological, meteorological or radiological science in Australia, South Africa or New Zealand; open to women graduates of Great Britain and Ireland under 27 years of age (extension for National Service). These offered by British F.U.W. (b) Rose Sidgwick Memorial Fellowship, $2,000, for a year's postgraduate study in the U.S.A. (open to natives of Great Britain not over 35 years of age). (c) Seven International Fellowships, given by the American A.U.W.: Helen Marr Kirby, $1,500; Mary E. Woolley, $1,500; Ohio State, $1,500; Virginia C. Gildersleeve, $1,500; Alice Hamilton, $1,500; Aurelia Henry Reinhardt, $2,000; all for a year's research in some country other than the holder's own; candidates should have been engaged in research for at least one year. Ida H. Hyde Woman's Fellowship, $1,000, doctorate required; preference given to research in euthenics and eugenics. (d) International Grant for Study in U.S.A. for women of outstanding ability (graduate work, advanced research or special investigations), offered by American Association U.W.

Application forms and regulations from Research Applications, B.F.U.W., Ltd., 17a Kings Road, London, S.W.3. Completed applications, except for (d), due July 15, 1951.

UNIVERSITY OF BIRMINGHAM
(DEPARTMENT OF GEOLOGY)

Applications are invited for a Research Fellowship in Geology, to the value of £450 per annum, tenable from October 1, 1951. The normal period of tenure is three years. Applicants must have had postgraduate experience in research on some branch of geology or geophysics.

Three copies of application, stating proposed research and naming two referees, should be sent before July 7, 1951, to the undersigned, from whom further particulars may be obtained.

G. L. BARNES,
Deputy Secretary.

The University,
Edmund Street,
Birmingham, 3.

NATIONAL COLLEGE FOR HEATING, VENTILATING, REFRIGERATION AND FAN ENGINEERING
BOROUGH POLYTECHNIC
BOROUGH ROAD, S.E.1
RESEARCH SCHOLARSHIP

The Board of Governors invites graduates in engineering or physics, and other suitably qualified persons, to apply for the Research Scholarships awarded by the Institution of Heating and Ventilating Engineers and tenable at this college. The Scholarship is of the value of £400 for one year, but there is a possibility of it being extended for a further period. The Scholar will be required to undertake research into some problems connected with heating and ventilating, and the work so done may be used, if he desires, as the basis for a thesis for a higher degree.

Applications, giving the candidate's qualifications and experience, should be made as soon as possible to the undersigned.

FREDK. J. PACKER,
Clerk to the Governors.

UNIVERSITY OF LONDON
A. H. BYGOTT SCHOLARSHIP, 1951

Applications are invited from registered medical practitioners (preferably those who are serving in the Public Health Departments, or who hold short-term Service Commissions in H.M. Forces, or who expect to enter the Public Health field) for the above Scholarship. The Scholarship is of the value of £200 and is tenable at the London School of Hygiene and Tropical Medicine for one year for the course for the Academic Postgraduate Diploma in Public Health. Remission of fees will be granted to the holder of the Scholarship. Application must be made by July 1, 1951.

Application forms and further particulars may be obtained from the Academic Registrar, University of London, Senate House, W.C.1.

THE ROYAL SOCIETY, ARMOURERS AND BRASIERS' COMPANY
RESEARCH FELLOWSHIP IN METALLURGY

The Secretaries of the Royal Society are prepared to receive applications for the above Research Fellowship. The successful candidate will be required to enter upon, and devote his whole time to, a course of research, which must be connected with base metals and alloys, and preferentially those used in connection with the Ancient Crafts of the Company of Armourers and Brasiers. The research is to be carried out under the scheme approved by the Royal Society and the Armourers and Brasiers' Company, particulars of which can be obtained from the Royal Society. The appointment will be for two years in the first instance from October 1, 1951, but may subsequently be extended to a maximum of five years. The stipend will be £850 per annum, with superannuation benefit.

Applications must be received at the Royal Society not later than June 30, 1951, and should be made on forms obtainable from the Assistant Secretary of the Society. Applicants must give three references and furnish particulars of their academic qualifications and of the research work already carried out by them. They should also give an outline of the research work which they propose to undertake.

The Royal Society,
Burlington House,
London, W.1.

UNIVERSITY OF SHEFFIELD

Applications are invited for the John Stokes Research Fellowship. The value of the Fellowship is £500 a year, and it is normally tenable for three years, which may be extended by a further two years or less. It is a full-time appointment. The Fellow is required to carry out in one of the departments of Sheffield University Medical School, or in a teaching hospital associated with the Medical School, original research work in some branch of medical science approved by the advisory committee. A candidate need not hold a registrable medical qualification.

Applications (three copies), indicating the line of research proposed by the applicant, and including the names and addresses of three referees, and, if desired, copies of not more than three testimonials, should reach the Registrar, the University, Sheffield, 10, by July 14, 1951. Official application forms are not provided.

A. W. CHAPMAN,
Registrar.

NATIONAL COLLEGE FOR HEATING, VENTILATING, REFRIGERATION AND FAN ENGINEERING
BOROUGH POLYTECHNIC
BOROUGH ROAD, S.E.1
WILLIAM NELSON HADEN SCHOLARSHIP

In conjunction with the Institution of Heating and Ventilating Engineers, the Board of Governors of the College propose to make an award of the William Nelson Haden Scholarship, which has been established to enable the holder to follow a course of advanced study or research in heating or air conditioning during the academic year 1951/2. The Scholarship is tenable at this college and is of the value of £250. Candidates should be graduates in engineering or physics, or should possess some other suitable qualification.

Applications, giving the candidate's qualifications and experience, should be made as soon as possible to the undersigned.

FREDK. J. PACKER,
Clerk to the Governors.

FOR SALE AND WANTED

CALCULATOR, ODHNER PORTABLE, 13-digit, back transfer, perfect order; sale, £50.—Box 574, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

LARGE EARTHWORMS, MEAL WORMS, Maggots. Ample supplies always available: 10s. and 20s. per tin, carriage paid. Despatch same day.—Tring Angling Supplies, Tring, Herts.

WANTED, SLIT-ULTRAMICROSCOPE OF Siedentopf and Zsigmondy, as described by Reilly and Rae, Physics Methods, Vol. II, page 189.—Full details, together with price and accessory equipment, should be forwarded to Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2.

REFLECTING OBJECTIVES

PROV. PATENT

The following objectives have been developed on designs of the Wheatstone Laboratory and Medical Research Council Biophysics Research Unit, at King's College, London.

No.	Focal length m.m.	Numerical Aperture	Price
4039	13	·28	£32·10·0
4035	2·6	·65	35· 0·0
4038	3·5	·65	35· 0·0

These objectives contain no lenses or correcting plates, having two reflecting surfaces only.

They are completely achromatic and transmit all radiations from vacuum ultra-violet to long wavelength infra-red. There is no spherical aberration.

They are specially suitable for all forms of microspectrography.

Full particulars will be sent on application.

R. & J. BECK LTD., 69 MORTIMER ST., LONDON, W.1

PURE ENGLISH FILTERING

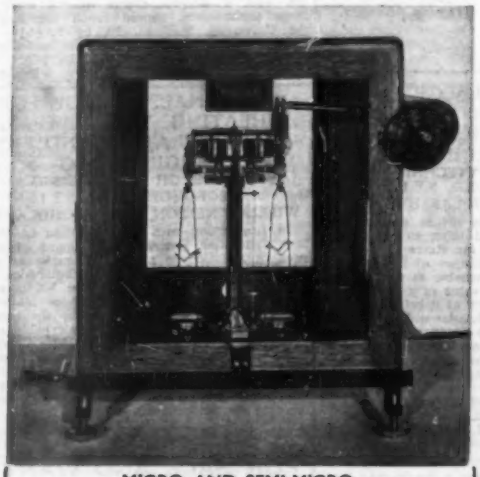
TWO CENTURIES OF PAPER MAKING

POSTLIP

mill 633

Pure rag Filter Papers

EVANS, ADLARD & CO LTD
WINCHCOMBE · GLOS

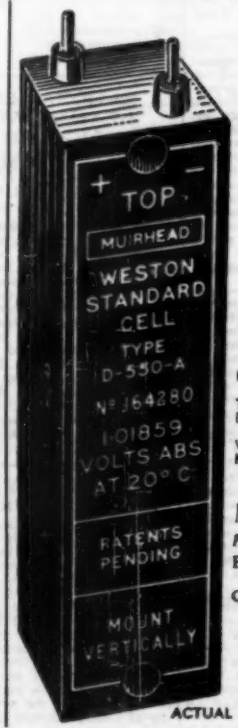


MICRO AND SEMI-MICRO
BALANCES
are a speciality of:

WILLIAM A. WEBB, LTD.

1-9 PERRYMANS FARM ROAD
NEWBURY PARK, ILFORD, ESSEX
who will gladly send details on request

Phone: VALentine 6370
Grams: Accuracy, Ilford
Cables: Accuracy, Ilford



ACTUAL SIZE

A MINIATURE STANDARD CELL

£1.13.0

(Post free in U.K.)

IMMEDIATE DELIVERY

Our other types of Standard Cells will interest you. Write for literature.

SPECIFICATION

E.M.F. 1·01859 VOLTS ABS. ±100μV AT 20°C
TEMP. COEFFICIENT 40μV/°C APPROX.
DIMENSIONS 3⅜" × ⅞" × ⅞" OVERALL [9·8cm. × 2·2cm. × 2·2cm.]
WEIGHT 2½ oz. [70 gm.]
MOUNTING MOULDED CASE—WITH PANEL AND CHASSIS FIXING HOLES

MUIRHEAD & Co. LTD.
Precision Electrical Instrument Makers
BECKENHAM · KENT · ENGLAND
Telephone : Beckenham 0041
Grams & Cables: MUIRHEADS ELMERS-END

PRECISION
MUIRHEAD
ELECTRICAL INSTRUMENTS

Printed in Great Britain by Fisher, Knight & Co., Ltd., The Gainsborough Press, St. Albans, and published by Macmillan & Co., Limited, at St. Martin's Street, London, W.C.2, and The Macmillan Co., 60 Fifth Avenue, New York 11, N.Y., U.S.A.—Saturday, June 9, 1951.